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The perception of volcanic risk in Kona communities from Mauna Loa and Hualālai volcanoes, Hawai'i

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Abstract

Volcanic hazards in Kona (i.e. the western side of the island of Hawai'i) stem primarily from Mauna Loa and Hualālai volcanoes. The former has erupted 39 times since 1832. Lava flows were emplaced in Kona during seven of these eruptions and last impacted Kona in 1950. Hualālai last erupted in ca. 1800. Society's proximity to potential eruptive sources and the potential for relatively fast-moving lava flows, coupled with relatively long time intervals since the last eruptions in Kona, are the underlying stimuli for this study of risk perception. Target populations were high-school students and adults ($n = 462$). Using these data, we discuss threat knowledge as an influence on risk perception, and perception as a driving mechanism for preparedness. Threat knowledge and perception of risk were found to be low to moderate. On average, fewer than two-thirds of the residents were aware of the most recent eruptions that impacted Kona, and a minority felt that Mauna Loa and Hualālai could ever erupt again. Furthermore, only about one-third were aware that lava flows could reach the coast in Kona in less than 3 h. Lava flows and ash fall were perceived to be among the least likely hazards to affect the respondent's community within the next 10 years, whereas vog (volcanic smog) was ranked the most likely. Less than 18% identified volcanic hazards as amongst the most likely hazards to affect them at home, school, or work. Not surprisingly, individual preparedness measures were found on average to be limited to simple tasks of value in frequently occurring domestic emergencies, whereas measures specific to infrequent hazard events such as volcanic eruptions were seldom adopted. Furthermore, our data show that respondents exhibit an 'unrealistic optimism bias' and infer that responsibility for community preparedness for future eruptions primarily rests with officials. We infer that these respondents may be less likely to attend to hazard information, react to warnings as directed, and undertake preparedness measures than other populations who perceive responsibility to lie with themselves. There are significant differences in hazard awareness and risk perception between students and adults, between subpopulations representing local areas, and between varying ethnicities. We conclude that long time intervals since damaging lava flows have occurred in Kona have contributed to lower levels of awareness and risk perceptions of the threat from lava flows, and that the on-going eruption at Kīlauea has facilitated greater awareness and perception of risk of vog but not of other volcanic hazards. Low levels of preparedness may be explained by low perceptions of threat and risk and perhaps by the lack of a clear motivation or incentive to seek new modes of adjustment.

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1. Introduction

Hawai'i's coastal communities are subject to a wide range of frequent and infrequent natural hazards (Fletcher et al., 2002) – floods, tsunami, storms, extreme weather, seismicity and volcanic eruptions (Hamnett et al., 1993, 1996). As a consequence of rising population densities, increasingly sophisticated facilities, and increasingly complex social and economic infrastructure (Burby, 1998; Johnston et al., 1999), Hawaiian society is growing increasingly vulnerable to experiencing detrimental consequences from natural hazard activity. This vulnerability, coupled with the unpredictability of natural hazards, in regard to nature, scale, timing, duration, and location, increases the importance of increasing community resilience. A key element of the latter concerns ensuring communities and their members are well prepared.

One barrier to hazard readiness is incomplete understanding of the factors that influence individual and societal preparedness, and of how they react to outreach activities prior to these crises. Hazard mitigation strategies typically focus on the physical attributes (e.g. the magnitude, frequency and physical processes of natural hazards, and on engineering and building design), but rarely consider the meaning this has for people or its relationship to risk reduction behavior. The importance of this relationship is heightened by the fact that technological mitigation measures that increase objective safety may lead to overconfidence and risky behavior (risk homeostasis, Adams, 1995). Similarly, the dissemination of scientific information by experts within outreach programs that focus only on supplying accurate information to the public, without considering how recipients will react to that information and whether they will use it effectively in the future, ironically can also reduce the perceived need for preparedness (Paton et al., 2000).

People's acceptance of their vulnerability can increase warning effectiveness and improve preparedness (Mileti and Sorensen, 1990; Perry and Lindell, 1990; Lindell and Perry, 1992; Mileti and Fitzpatrick, 1992; Mileti and O'Brien, 1993; Lindell, 1994; Nathe et al., 1999), but this link is often uncertain and tenuous (Lindell and Whitney, 2000; Johnston et al., 1999). The dissemination of information related to natural hazards may promote hazard awareness among individuals in a community, but the widely maintained assumption that increasing an individual's awareness of hazards will result in an increase in their levels of preparedness for natural hazards is not always justified and has fallen well below expectations (Lindell and Whitney, 2000; Paton et al., 2000). No direct relationship between awareness and risk perception has been unequivocally demonstrated. To make matters worse, people confronted with complex issues about which they have a poor understanding, such as volcanic hazards, may transfer *all* responsibility for their protection to the requisite experts, e.g. the U.S. Geological Survey Hawaiian Volcano Observatory or Civil Defense agencies in the case of Hawai'i (Paton et al., 2001a), with reduction in preparedness (Mulilis and Duval, 1995; Lindell and Whitney, 2000). These observations highlight the need to articulate people's understanding of scientific information and technical mitigation measures before embarking on a strategy that involves using this information to facilitate preparedness. Adopting this approach gives scientific and emergency management agencies the opportunity to correct misconceptions first. They can then develop risk communication strategies that build on community knowledge, beliefs, needs and expectations (rather than providing information that reflects only the knowledge and expectations of the scientific community).

Several studies have measured understanding and perception of volcanic hazards and risk during periods of quiescence (D'Ercole et al., 1995; Johnston and Houghton, 1995; Perry, 1990), after a volcanic crisis (Murton and Shimabukuro, 1974; Kartez, 1982; Saarinen and Sell, 1985; Yoshii, 1992), and before and after a volcanic crisis (Johnston et al., 1999). However, few studies have been conducted in Hawai'i, whose varied ethnicity, wide cultural framework, and volcanism are unique in the world.

While work on perceptions of risk or preparedness for volcanic hazards in Kona is absent from the literature, some work has been done on Kīlauea volcano (Fig. 1a) in the eastern portion of the island (e.g. Lachman and Bonk, 1960; Murton and Shimabukuro, 1974). This study evaluates the perceptions of volcanic hazards from Mauna Loa and Hualālai volcanoes in Kona (Fig. 1d).

1.1. Kona

Our study area lies principally in the political districts of North and South Kona, collectively called Kona (Fig. 1d), which form the western portion of Mauna Loa and of Hualālai shield volcanoes. Both districts in Kona have been adversely impacted by lava flows during historical eruptions of Hualālai and Mauna Loa and by gas emissions from an on-going, 20-year old eruption at Kīlauea. The populations of North and South Kona in 2000 were 28 543 and 8589, respectively (County of Hawaii, 2000, see table 1.5). North Kona includes the second largest city on the island (Kailua-Kona, population 9870; County of Hawaii, 2000, see table 1.7) and is more densely populated than South Kona. Risk to society in Kona as a consequence of future volcanic activity at Mauna Loa and Hualālai has increased sharply since the last eruptions in the area, due to growth in population, infrastructure and its growing economic relationship with tourism. Most of Kailua is within 15 km of potential eruptive sources. South and North Kona are two of the three greatest areas of concern on the island identified by the state's Lava Flow Hazard Mitigation Plan Technical Committee (Hawai'i State Civil Defense, 2002).

1.2. Natural hazards and Kona

Volcanic hazards may have a more prolonged impact than other hazards, because of the relatively long durations of precursory and eruptive activity. For example, storms arrive with high wind and rain but generally pass within a few days, and tsunami pass after several hours have elapsed. On the other hand, eruptions at Mauna Loa have had durations of from less than 1 day to 4.5 years of almost continual activity during the summit eruption of 1872–1877, and flank eruptions have had durations from about 5 days to 450 days (Lockwood and Lipman, 1987). The most recent lava flows from Hualālai may have had durations of hours to months (Kauahikaua et al., 2002). Hazards with unpredictable, but potentially such prolonged, duration are thus a special case. The consequences of prolonged interaction with social, economic and physical infrastructure require special attention. Modern hazard mitigation campaigns tend to focus on building resilience in advance rather than compensating retrospectively for loss and deficit (Omar and Alon, 1994; Tobin, 1999; Van den Eyde and Veno, 1999; Violanti et al., 2000). A valid question in Kona and elsewhere on the island is how can society best adapt to future eruptions of varying durations?

1.3. Volcanoes

Mauna Loa has erupted 39 times since 1832 (Barnard, 1995), on average every 4.4 years. Subaerial eruptions in 1851, 1859, 1916, 1919, 1926, 1949, and 1950 produced lava flows in Kona (Fig. 1c), and a submarine eruption occurred offshore of Kona in 1877 (Moore et al., 1985). The most recent eruption of Mauna Loa in Kona occurred during a 3-week period in 1950 and produced destructive lava flows (Macdonald, 1954; U.S. Geological Survey, 2000). Mauna Loa last erupted in 1984 and threatened Hilo, in the eastern portion of the island (Lockwood et al., 1987; Trusdell, 1995). Hualālai erupted twice in Kona in ca. 1800 (Kauahikaua et al., 2002), but the details of these eruptions are less well documented than those for eruptions of Mauna Loa. Recurrence intervals for Holocene time are on the order of 50 years (Moore et al., 1987). Hualālai has no summit caldera, unlike Mauna Loa, where signifi-

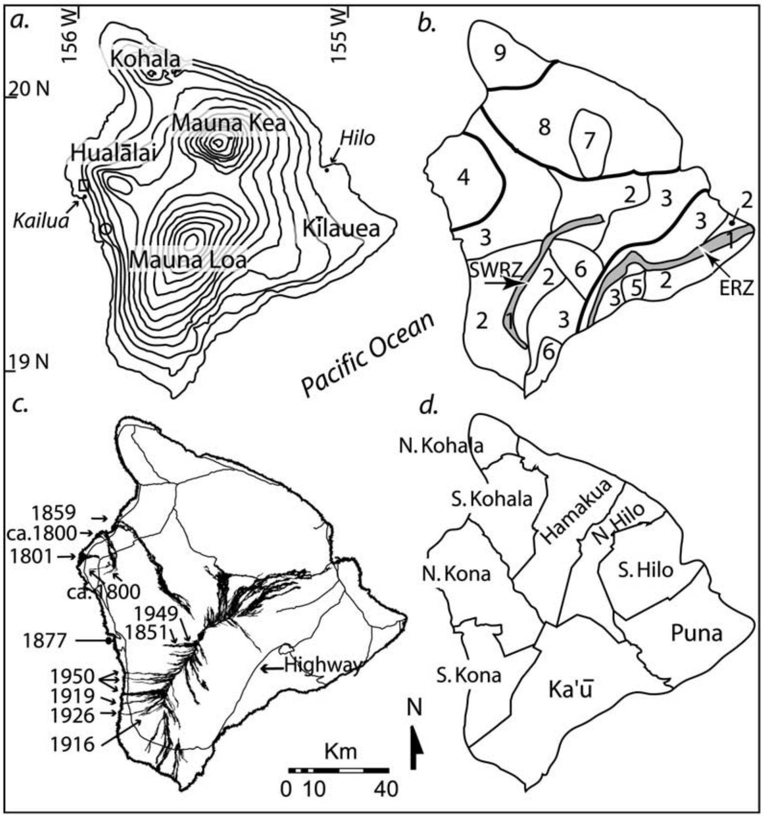

Fig. 1. Generalized maps of the island of Hawai'i. (a) Topography (contour interval = 1000 feet), volcanoes, major cities, and high schools surveyed (square = Kealakehe; circle = Konawaena). (b) Lava-flow hazard zones. Bold lines outline volcanoes. (c) Dates of selected recent lava flows; locations of main roads and highways. (d) Political districts. After U.S. Geological Survey, 1997a.

cant volumes of lava can be impounded within the caldera. The current lava-flow hazard-zone map (Wright et al., 1992) indicates that Hualālai is less hazardous than Mauna Loa and Kīlauea, but future refinements to the hazard zone map at Hualālai (Kauahikaua et al., 2002) may increase hazard levels at this volcano.

1.4. The nature of volcanic hazards in Kona

Mullineaux and Peterson (1974), Mullineaux et al. (1987), Heliker (1990), and Wright et al. (1992) described volcanic hazards on the island of Hawai'i and produced hazard-zone maps for lava flows, tephra fall and volcanic gas emissions. Mullineaux et al. (1987) suggested that lava flows are the greatest hazard to property. Lava flows occur more frequently than ash fall in Kona, but they are less frequent than gas emissions, which are derived principally from Kīlauea. The lava-flow hazard zones (Fig. 1b) are ranked 1–9, with 1 the most hazardous and 9 the least hazardous (Wright et al., 1992). South Kona includes zones 1, 2 and 3. North Kona includes mostly zones 3 and 4. All of Hualālai is currently in zone 4. Greater values for slope (Fig. 1a) and effusion rates compared to Kīlauea contribute to faster-moving lava flows in Kona. The fastest lava flow recorded in Hawai'i occurred in South Kona during the 1950 eruption of Mauna Loa. One lava flow traveled 24 km in 2.5 h, an average rate of 9.6 km h^{-1} (Macdonald, 1954; U.S. Geological Survey, 2000). The existence of faster flows during Hualālai's last eruptions in ca. 1800 is debatable (Kauahikaua et al., 2002), but certainly steeper slopes enhanced local flow-front advance rates. Then and in the future, steep slopes and high effusion rates combine to produce relatively fast-moving lava flows, which pose heightened concern for society in Kona.

Vog is dominated by aerosol particles in Kona (U.S. Geological Survey, 1997b). Adverse effects of vog in Kona include physical, chemical, and biological damage to plants, water supplies, and respiratory systems. On-going vog problems in Kona are derived primarily from the 20-year-old eruption of Kīlauea, but problems also occurred during the Mauna Ulu eruption of Kīlauea in 1969–1974 (Mullineaux et al., 1987). Tephra fall from Hawaiian volcanoes is generally of greatest consequence near the eruptive sources and thins with distance from source. Tephra from explosive eruptions of Hualālai has not fallen in dense areas of Kailua-Kona and is generally confined to areas of less than about 10 km^2 from the vents (Moore et al., 1987). Eruptions of Mauna Loa have not produced damaging amounts of ash in Kona.

Mullineaux et al. (1987) discussed issues surrounding limitations of mitigating lava flow compared to ash and gas hazards. In Hawai'i and elsewhere, rock walls have been hastily constructed to stop or retard the advance of lava flows, earthen dams have been constructed to retain lava, earthen diversion barriers and channels have been constructed and excavated to divert lava, bombs have been dropped to interrupt lava, and water has been sprayed on flows to retard their movement (Jaggar, 1945; Macdonald, 1958, 1962; Wentworth et al., 1961; Lockwood and Torgerson, 1980; U.S. Army Corps of Engineers, 1980; Colombrita, 1984; Barberi et al., 1993). More frequently though, people that have been threatened by lava flows in Hawai'i turn simply to evacuation, although other alternatives have involved appeals to the supernatural. Murton and Shimabukuro (1974) reported that evacuation is the only emergency adjustment with which Puna residents are familiar and that the warning and emergency system is 'premised on the belief that if an inhabited area is threatened by lava, evacuation will take place'. Furthermore, they reported that, apart from evacuation, the most widely used of all other adjustments is the 'bearing of losses when they occur'. Engineered measures are somewhat controversial and may not be realistic options to mitigate lava-flow hazards in Kona (Mullineaux et al., 1987; Moore et al., 1987), where slopes are steep and travel times from source to ocean may be only a few hours or less, unless the measures are implemented well in advance of eruptions. Diversion of lava into otherwise unthreatened areas is a particularly sensitive issue. There are no current plans to implement engineered measures (e.g. diversion barriers) to protect against lava-flow hazards in Kona (Hawai'i State Civil Defense, 2002).

2. The survey

2.1. Survey method

The questionnaire was designed for students, their parents or guardians, and adults at large. The questionnaire used in this study was modified from one developed for studies of volcanic hazard risk perception in New Zealand (Ronan and Johnston, 2001). The questionnaire was reviewed by scientists and emergency managers, pretested, and precoded.

Our data were derived from five separate groups: 9th-grade students at (1) Kealakehe High School ($n=132$) on Hualālai in North Kona and (2) Konawaena High School ($n=104$) on Mauna Loa in South Kona (Fig. 1a); (3 and 4), parents or guardians of these students ($n=117$ and 44), respectively; and (5) adults at large (derived from a random survey of Post Office box holders ($n=51$) and a survey of residents of Kona awaiting flights to Kona at the international airport in Honolulu ($n=14$). We refer to these groups as North and South Kona students, North and South Kona parents, and Adult-at-large. Return rates were: students and airport samples (100%), North Kona parents (89%), South Kona parents (42%), and mail-out adults (10%). The district in which a student attends school is a reasonable proxy for the district in which he/she resides.

2.2. Survey purpose

The survey was designed to evaluate experience with hazard events and educational programs, understanding of the emergency warning system, levels of hazard awareness, perceptions of volcanic risk, and levels of preparedness in Kona, and to identify potential underlying causes and influences. Hazard awareness or knowledge influences risk perception, and perceptions are one driving mechanism for preparedness (Green et al., 1981; Perry and Lindell, 1990; Perry and Hirose, 1991; Lindell, 1994; Johnston et al., 1999). Knowledge of a threat relates to salience of the hazard, levels of past damage incurred, and the extent and timing of contact with hazard information. Perceived risk has been linked to proximity to the hazard source, perceived likelihood of future disasters, and the perceived extent of impact, as well as past experience in disasters. Hazard adjustment reflects perceived risk, the information received regarding protective measures, extent of past damage, self-efficacy (the individual's perception of their ability to play a role), and outcome expectancy (the notion that a community can mitigate hazard consequences; Bishop et al., 2002; Lindell and Whitney, 2000; Paton, 2000).

The difference in lapsed time since the last eruptions of Mauna Loa and Hualālai to affect Kona provides an opportunity to compare threat knowledge and risk perception as a function of the time since the eruptions. Potentially, perception of which volcano (Mauna Loa or Hualālai) is most likely to erupt should be inversely related to the repose time since the last significant eruption.

2.3. Respondents (or sample)

A total of 462 questionnaires were returned (236 students, 226 adults). Demographic data for the student and adult samples, respectively, are: mean age (14.7 years, sd = 0.763 and 44.4 years, sd = 9.389); gender (male = 52.8% and 31.1%). Home and land ownership for adults only is: 57.1% own their home, 31.6% rent, 19% own land in another town and 16% own a second home. Ethnicity, on average, is: White 41.1%; Hawaiian, part-Hawaiian and Pacific Islander 36.5%; Japanese 16.7%; Filipino 12.2%; other 29.6%. Demographic characteristics, while not corresponding exactly to U.S. Census Bureau (2000) data, do provide a representative profile of major ethnic groups and allow the tentative generalization of these data to the wider population.

For the North and South Kona parent groups, about 75–76% were female ($n = 119$), compared to 53% for the Adult-at-large group. Female parents or guardians may be more inclined than their male counterparts to participate in surveys administered through their children's schools. Moreover, 68% of single-parent families in Kona (24%) include female householders (County of Hawaii, 2000, see table 1.20).

2.4. Knowledge of the volcanic hazard

We explored threat knowledge through questions related to past perceptions of current and

Table 1
Perceptions that each volcano could erupt again by five survey groups[a]

	N Kona St $n = 131$ (%)	S Kona St $n = 100$ (%)	S Kona P $n = 42$ (%)	N Kona P $n = 116$ (%)	Adult $n = 65$ (%)	Total $n = 454$ (%)
Kīlauea	63.4	72.0	66.7	68.1	70.8	67.8
Mauna Loa	29.8	45.0	57.1	56.0	73.8	48.7
Hualālai	50.4	20.0	57.1	60.3	55.4	47.6
Mauna Kea	23.7	24.0	33.3	21.6	36.9	26.0
Kohala	10.7	15.0	2.4	6.9	7.7	9.5
None will erupt again	8.4	11.0	7.1	6.9	3.1	7.7

[a] N = North, S = South, St = Student, P = Parent, Adult = Adult-at-large.

future volcanic activity on the island, awareness of the most recent eruptions, understanding of the speed with which lava may flow, experience in hazard events, awareness of the lava-flow hazard zone in which people live, and prior contact with hazard information.

Knowledge of volcanism on the island is high but for Kona specifically is low. For example, 89.6% ($n=387$) of respondents recognized Kīlauea as the volcano that has been erupting almost continuously since 1983, although 10.4% ($n=45$) were unaware of this fact. This lack of awareness is shared even by people who have resided in Kona for up to 43 years. Knowledge of the threat posed to society in Kona as a consequence of future eruptions of Mauna Loa and Hualālai is low. When asked, 'Which volcanoes do you think could erupt again', about two-thirds (68%) selected Kīlauea, but only a minority believed Mauna Loa and Hualālai could erupt again (Table 1). Furthermore, a surprising 8% ($n=35$) indicated that 'none will erupt again'. Chi-square values indicate significant statistical differences in perceptions of future activity of Mauna Loa ($\chi^2=39.485$; $P=0.000$) and Hualālai ($\chi^2=41.616$; $P=0.000$). For the student groups, perception is related to proximity to the hazard source (in this case the volcano on which each student group attends school and presumably resides; contrast Mauna Loa and Hualālai data in Table 1). Our data can be contrasted with the findings of Murton and Shimabukuro (1974), who reported that 12% of the respondents in Puna District did not expect eruptions of Kīlauea in the future (79% did) – a surprising finding to us, given the recent and frequent activity of Kīlauea at that time.

The low response for Kīlauea in our sample is unlikely related to misinterpretation of our question, because the five groups in Table 1 did not differ in their opinion ($\chi^2=2.285$; $P=0.684$). Moreover, among the 90% who were aware of the long-term activity at Kīlauea, 74.1% ($n=286$) perceived that Kīlauea could erupt again, and chi-square analysis indicates that, again, the five groups did not differ in their perceptions ($\chi^2=1.192$, $P=0.879$). It is not clear why, among the subsample that knew that Kīlauea has been erupting continuously since 1983, 26% would perceive that Kīlauea could not erupt again. The data may reflect a misperception that, once Kīlauea stops erupting, it could not erupt again.

When asked, 'Which two of four volcanoes are most likely to erupt next', Mauna Loa and Hualālai were perceived to be more likely to erupt next than Mauna Kea and Kohala; this is a realistic perception. However, only 71% ($n=312$) selected Mauna Loa, and two-thirds ($n=289$) selected Hualālai. Nearly one-third of the respondents (mostly from South Kohala District) selected Mauna Kea. These perceptions of which two volcanoes are most likely to erupt is linked to proximity to the volcano. Chi-square analyses suggest that perceptions of future activity at Mauna Loa and Hualālai are not proportional to the length of time respondents have lived in Kona.

Perceptions of the timing of recent eruptions also show limited understanding. Lava flows emplaced during the latest eruptions of Hualālai in ca. 1800 remain largely barren in Kona, and portions of the international airport and major highways are built on these flows. When we asked, 'When was the last time Hualālai volcano erupted', only one-third answered correctly (i.e. about 200 years ago (Table 2)). Less than one-quarter answered correctly when we asked, 'When was the last time lava from Mauna Loa flowed into the ocean in Kona' (i.e. about 50 years ago). The data show a sharp contrast between the responses of the student and adult subpopulations (Table 2). The differences in awareness between adults and students are surprising, given the relative exposure of these two subpopulations to hazard education programs, and suggests current programs perhaps do not focus on Kona specifically. Moreover, we found that, among those who indicated that they have been involved in a hazard education program or had studied lava flows in school, overall awareness of the eruptions was no higher than the total shown in Table 2. This suggests that hazard education may not have focused on the most recent activity in Kona. This low awareness of the most recent volcanic activity in Kona contrasts with the much greater awareness of activity at Kīlauea.

Table 2
Awareness of years since last eruptions of Hualālai (about 200 years ago) and of Mauna Loa (in Kona, about 50 years ago) by student and adult subgroups

	Mauna Loa			Hualālai		
	Students $n=230$ (%)	Adults $n=212$ (%)	Total $n=442$ (%)	Students $n=229$ (%)	Adults $n=211$ (%)	Total $n=440$ (%)
About 500 years ago	8.7	9.0	8.8	4.8	3.8	4.3
About 200 years ago	–[a]	–[a]	–[a]	19.7	46.4	32.5
About 50 years ago	10.9	35.4	22.6	–[a]	–[a]	–[a]
About 20 years ago	4.3	7.5	5.9	7.4	2.8	5.2
Don't know	76.1	48.1	62.7	68.1	46.9	58.0
Total	100	100	100	100	100	100

[a] Not applicable.

The potential high velocity of lava flows in Kona is a major issue for hazard mitigation. We asked, 'In a future eruption, how quickly could a lava flow reach the ocean in Kona'. The data indicate that about one-third (33.9%, $n=146$) selected the correct answer (i.e. 3 h or less), while slightly more (36.2%) selected 12 h. The remainder selected longer times of 3 days (5.8%, $n=25$) and 1 month (24.1%, $n=104$). Amongst those indicating involvement in a hazard education program or that had studied lava flows in school, overall awareness was unchanged (33%). We infer that respondents have a poor understanding of the time scale with which lava flows can travel, and again, that education was not focused on Kona's situation.

These data are particularly informative in regard to preparedness. Most respondents live between eruptive sources and the ocean, but it is not clear if people conflate time to reach the ocean with time to reach them or to impact on them. If the warning time exceeds that required to make what they think are the necessary preparations, pre-eruption preparedness will decline. Pre-eruption preparedness is even less likely for those recording 1 month (24%).

Our data show that, on average, direct experience of natural hazard events that have damaged the respondent's neighborhood is low (28.3%, $n=122$, missing data = 16) and very low for volcanic hazards. Of the 122 with experience, less than 5.8% ($n=7$) indicated that either vog, lava flows, or ash fall had damaged their neighborhood. However, in a subsequent question, we asked respondents to 'List any damage that vog has caused you or your family's health or property'. A slight majority of adults (52.3%, $n=111$) and one-third (33.0%, $n=73$) of students identified impacts on health. These data could have implications for the nature of preparedness programs. Rather than focusing on hazard characteristics per se, programs may be more effective by focusing on the interaction between these characteristics and community needs. Very few respondents or their relatives have been threatened or affected by a damaging eruption. Only 36 of 422 respondents (8.5%) answered in the affirmative.

Hawaiian eruptions often allow relatively easy access to observe passive lava flows without explosive activity and ash fall. Paton et al. (2001b) and Lindell and Perry (1992) found that only direct experience in hazard events was found to influence risk perception, as opposed to vicarious experience (Sjöberg, 2000). About one-third (37.7%, $n=170$) indicated that they had seen active lava flows. This is considerably less than 85% of Puna residents who reported having experienced a number of eruptions on Kīlauea (Murton and Shimabukuro, 1974).

Knowledge of the lava-flow hazard zones is at a very low level. Lava-flow hazard zones are defined for the entire island, i.e. all structures are located within a zone or lie along the boundary of two or more zones. The salience of lava-flow hazards may be readily evaluated by the percentage of respondents who are aware of the zone in which they live. Only 15% ($n=44$) of respondents indicated they knew the lava-flow hazard zone in which they resided. In reality only 8 of these identified a possible legitimate zone (13 did not respond). The data question utility of the zones for residential property owners. Knowledge of the hazard zone is higher among those with prior hazard experience and is influenced by ethnicity. For example, Japanese respondents were about four times less likely to know the zone in which they lived than the mean of other ethnicities (17%). Knowledge also appears to be proportional to the degree of lava-flow hazard in which respondents live. For example, 38.5% ($n=10$) in hazard zones 2 and 3 were aware, 13.9% ($n=26$) in zone 4 and 8.8% ($n=3$) in zone 8. Sample sizes were too small to test for statistical significance. These data apply to the Adult-at-large and Kealakehe groups.

2.5. Hazard education

A slight majority (50.8%, $n=229$, missing data = 11) of respondents indicated they have been involved with a hazard education program that informed them about the types of hazards included in this survey. Students claimed greater involvement (59.7%, $n=139$) than adults (41.3%, $n=90$, $\chi^2=15.210$, $P=0.000$). 86.1% of students ($n=118$) selected school as the source of the information compared to 64.0% ($n=57$) of adults. On average 30.1% ($n=68$) selected Hawai'i Volcanoes National Park (HVNP), and 13.7% ($n=31$) could not remember. However, only 5.1% ($n=7$) of students selected other sources compared to 49.4% of adults ($n=44$). The latter data suggest that adults receive information from sources not recognized by students.

The extent to which lava-flow, vog, and ash-fall hazards have been taught or discussed at school is disproportional, with an emphasis on lava flows. A majority of students (53.7%, $n=124$) indicated they had studied or discussed lava flows, compared to only about one-third of adults (34.9%, $n=66$). Similarly, more than twice as many students had studied or discussed vog than adults (31.2%, $n=72$ compared to 14.8%, $n=28$). For ash fall, student and adult responses were similar (average = 18.1%, $n=76$).

The U.S. Geological Survey (USGS) Hawaiian Volcano Observatory (HVO) disseminates information through a weekly newspaper column titled Volcano Watch, which is published in local newspapers and posted on the internet (since late 1994). To evaluate exposure to Volcano Watch, which is devoted to topics such as volcanic hazards and processes on the island of Hawai'i and to informational topics related to other volcanoes in the U.S. and overseas, we asked, 'Did you know that Volcano Watch is a Big Island newspaper column on volcanoes' to which on average 40% ($n=171$) answered in the affirmative. The difference in student and adult responses is statistically significant (32.1% versus 48.1%, $\chi^2=11.391$; $P=0.001$). Of those respondents who answered in the affirmative, those who indicated they read Volcano Watch last week included 41.7% ($n=101$) of adults, but only 19.4% ($n=13$) of students (average = 32.5%, $n=53$). Similarly, 38.8% ($n=26$) of students indicated they never read it compared to 0% for adults. On average, 27% ($n=44$) read Volcano Watch last month and a further 24.5% read it last year. The data illustrate the contrast in use of different sources of hazard information among students and adults. This is not the same as utilizing it or even rendering it meaningful in the manner anticipated. More work is needed to examine the factors that influence interpretation and how it is rendered salient.

People believe HVNP is a significant source of hazard education. A majority (52.3%) of student respondents indicated they have participated in a 3-day field trip to HVNP (mostly as 5th- or 6th-grade students), and about 80% ($n=168$) of the adults indicated they have visited HVNP and learned about volcanic hazards. We did not evaluate what type of educational material the adults were exposed to at HVNP, but a question remains, what did they learn from displays and brochures versus what was taught by HVNP personnel or other officials? A concern is that respondents may wrongly associate their mere presence inside HVNP with hazard education, or confuse their knowing where information could be obtained with their actual knowledge (Paton et al., 2000).

We asked respondents to rate the consistency of all volcanic information that they had received in Hawai'i. Adults (51%, $n=105$) perceive information to be more consistent than students (30%, $n=64$), whereas students (43.2%, $n=92$) are more uncertain about the consistency than are adults (25.2%, $n=52$). This is surprising, since a significantly greater percentage of students indicated that they had studied lava flows and vog in school. The data suggest a need for clarification of some information, and whether this could reflect other factors (e.g. independent search through the web), which furnishes information that is less accurate or unrelated to the Hawaiian situation. On average, 13.1% had not heard anything and 12.2% indicated the information was fairly to very inconsistent.

To evaluate preferred sources of information, we asked participants where they would look for information about future volcanic activity on the island. Only one source (television and radio) is favored by a majority of respondents (58.4%, $n=261$); 34.5% ($n=154$) selected USGS HVO website, a similar number selected Civil Defense, and 30.9% ($n=138$) selected 'internet'. Between about 11% and 14% selected school, Police and Fire Department, telephone book and local library. An interesting issue is the possibility that respondents are recalling sources related to hazards with which they are familiar rather than describing actual preferences (Ballantyne et al., 2000). The latter authors conducted a pre- and post-volcanic education survey. Information during the pre-survey revealed that pamphlets in the mail box were identified by respondents as their preferred medium to receive hazard information. However, the subsequent evaluation of a pamphlet-based education strategy revealed that this medium proved highly unsuccessful. The authors inferred that people identified media as what they were familiar with rather than from thinking about the relationship between medium and effectiveness. This is supported by the large number of responses (937) to a question where respondents were not asked to make multiple selections.

2.6. Perceptions of risk

The public's perception of risk has been linked to proximity to the source of a hazard (i.e. Mauna Loa and Hualālai), perceptions of the likelihood of future disasters, and the extent of impact, as well as past experience in disasters. The island of Hawai'i is built of volcanoes, so society exists everywhere on some portion of the five volcanoes. In our survey, respondents live predominantly on Hualālai and Mauna Loa, but also on the lower flanks of Mauna Kea and Kohala. Respondents were found to have a good understanding of the two volcanoes nearest to their home and identified Hualālai (74.7%, $n=339$) and Mauna Loa (64.1%, $n=291$). Proximity of some respondents to Mauna Kea moderated responses for Hualālai.

To evaluate the popular perception of risk across a variety of hazards that occur in Kona, we asked participants, 'Thinking about the chances of property damage and loss of life or injuries, which are the two most likely hazards that could affect you at home, school (students only) and work (adults only)' (Fig. 2). Risk is generally perceived to be greatest at home, and lava flows are perceived to represent a greater threat than vog and ash fall. The responses may reflect the volume of information received about each hazard as opposed to an objective analysis of risk exposure among all the hazards, although this cannot be determined from the data.

To evaluate the perception of repose period, we asked, 'When do you think the next hazard events

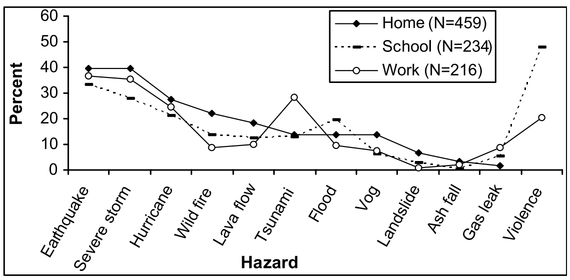

Fig. 2. Perception of risk for hazards at home, school and work. Gas leak includes chemical spill; violence includes violent incident at school (students only) or at work (adults only); storm includes with high winds and lightning.

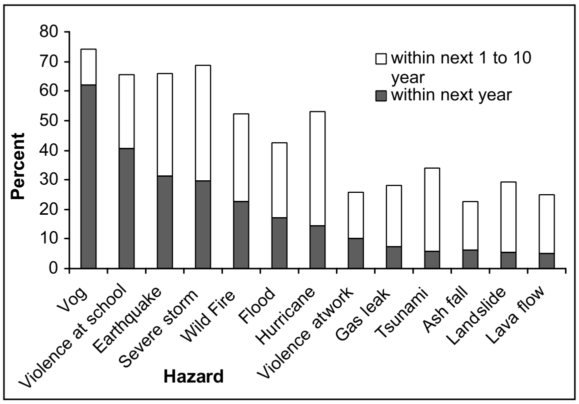

Fig. 3. Average perception of time until the next hazard event is likely to affect respondent's community. Gas leak includes chemical spill.

are likely to affect your community'? Results (Fig. 3) are shown for those perceiving that an event will occur 'within the next year' and 'within the next 1 to 10 years'. Responses for greater than 10 years are not shown but make up the residue. The results indicate that the times in which volcanic hazards are perceived to likely affect the respondent's community vary widely. Vog is considered to be the most likely hazard to affect the respondent's community within the next year, but ash fall and lava flows are among the least likely. For vog, the number of females (78%, $n=21$) selecting 'within the next year' was different from the 44% ($n=10$) of males. Data for vog are derived only from the Adult-at-large group. For lava flows, the percentage of students who selected within the next 1–10 years (31%, $n=71$) was statistically different from the responses of adults (18.1%, $n=39$; $\chi^2=10.585$, $P=0.005$) and suggests a greater perception of risk among students.

2.7. Preparedness

Data indicate that the majority of preparedness measures that have been adopted in Kona focus on frequent but low-impact household emergencies rather than infrequent but more damaging natural hazards. From a list of 21 preparedness measures, we asked respondents to select those measures that their family had taken. We then divided the measures into two groups, those that may also be used for frequent domestic emergencies (e.g. having a flashlight, first aid kit, fire extinguisher) and those applying only to infrequent hazard events (e.g. having the household water heater secured to the wall, buying extra insurance, having an emergency contact in another town, or having property inspected for vulnerability to natural hazards). The data do not represent preparedness measures taken to protect against a specific hazard, but they do show the tendency for people to adopt measures that are less time-consuming and less expensive to undertake (mean = 65.7%, sd = 16.0) rather than more involved and time-consuming measures (26.5%, sd = 9.6; Mileti and O'Brien, 1992). For frequently occurring hazards, adults consistently indicated levels of preparedness higher than did students, but for infrequently occurring hazards, students' perceptions of preparedness were higher in all but two of the preparedness measures.

The perception of preparedness of and within a community can have important implications for actual preparedness at the individual level. For example, Weinstein and Klein (1996) described an 'unrealistic optimistic bias' in which a majority of respondents rated themselves as being more prepared (less vulnerable) and more skilful than the average. While individuals may be aware of a need for greater preparedness within the community, the need is not recognized as applying to them. As a result, individuals may be less likely to participate in activities designed to increase preparedness and act on warning messages (Johnston et al., 1999). To evaluate the perception of preparedness, we asked, 'How prepared do you believe the following people and groups of people are for a damaging earthquake', using a scale ranging from 1 (very prepared) to 4 (not at all prepared). On average, our data indicate that respondents perceive themselves as less prepared (mean 2.61, sd = 1.047) than their family (2.54, sd = 1.039) and emergency management agencies (2.07, sd = 1.369), but more prepared than the community (2.85, sd = 1.217) in general and imply the presence of an unrealistic optimism.

Mulilis and Duval (1995) and Lindell and

Whitney (2000) found that a reduction in preparedness results when persons assign responsibility for their personal safety to others. To evaluate the perception of responsibility for preparedness for volcanic eruptions, we asked, 'Who should be responsible for preparing the community for future volcanic eruptions' (Table 3). These data are significant, in that respondents believe that individuals in the community are less responsible than the emergency management officials or agencies. This comes as no surprise; considering that, in the prior question, respondents perceived officials to be the most prepared for a damaging earthquake. The transfer of responsibility for oneself to others could reflect differences in expertise (Ballantyne et al., 2000) and the inference that those agencies that are funded by tax dollars to manage hazards should take responsibility for the safety of people in their community.

We found that, on average, only one-third of respondents indicated that their families had a plan of action for how to act in an emergency such as a lava flow, hurricane, or earthquake. This suggests that plans involving lava hazards may be even less common. Furthermore, only one-third had practiced what to do during an emergency at home; slightly more knew the location of an emergency evacuation shelter near their school or home.

In the Puna District on Kīlauea, Murton and Shimabukuro (1974) found that a few Hawaiians believed that a *kahuna* (priest) or Madam Pele (the volcano goddess) will tell them when an eruption will occur. In contrast, they reported that many *haole* (Caucasian) newcomers believed that scientific monitoring by the HVO can predict the occurrence of eruptions. The researchers also reported that many more people, especially old Hawaiians, offer gifts to Pele. Lachman and Bonk (1960) reported on belief in Pele during the 1960 eruption in Puna, but suggested that belief was not limited to any one religious creed, ethnicity, age level, or degree of education. To evaluate the association of Pele with volcanic eruptions, we asked, 'Who or what controls whether or not a Hawaiian volcano erupts'? For those selecting only one answer ($n = 376$), on average a majority (58.5%, $n = 220$) selected pressure beneath each volcano, whereas only 15% selected chance, 12.8% Pele, 9% God, and 4% other. Students (20.8%), especially in South Kona, were more likely to select Pele than adults (4.3%), whereas three-quarters of adults selected pressure beneath each volcano, compared to only 42% of students. 54 respondents chose to select multiple answers. Among these, 32 selected Pele, 31 God and 42 pressure. Together, the data suggest a mixed perception of the causes of volcanic eruptions in Hawai'i, with beliefs rooted in physical volcanic processes held by a good majority (61%), followed by spiritual beliefs in Pele and God by about one-third. Our findings show that belief in Pele is strongest among Spanish respondents. For example 44% ($n = 7$) of Spanish people selected Pele alone, Hawaiian (30%, $n = 8$), Filipino (22%, $n = 10$), and part-Hawaiian (20%, $n = 18$). Less than 13% of other ethnicities such as White, Japanese, and Portuguese selected Pele alone. The data suggest that belief in Pele as a controlling factor in volcanic eruptions is shared by a minority and agree with the finding of Lachman and Bonk (1960) that belief in Pele is not limited to

Table 3
Perception of responsibility for preparing the community for future volcanic eruptions by student and adult subgroups

	Students $n = 230$ (%)	Adults $n = 212$ (%)	Total $n = 442$ (%)	χ^2; P [a]
Civil Defense	78.7	89.2	83.7	8.843; 0.003
USGS, HVO	56.5	74.1	64.9	14.896; 0.000
Police, Fire departments	57.8	62.7	60.2	1.110; 0.292
Every individual in the community	49.1	58.5	53.6	3.886; 0.049

[a] χ^2 = Chi-square value; P = probability. Missing data = 20. USGS = U.S. Geological Survey. HVO = Hawaiian Volcano Observatory.

any one ethnic group. These data have significant implications for risk perception, preparedness, and attentiveness to public education.

3. Discussion

3.1. Awareness and preparedness

Overall, our data suggest that knowledge of the threat to Kona from eruptions of Mauna Loa and Hualālai is low. Why is this so? Lack of exposure to hazard programs may not be the cause – a majority of respondents indicated they had participated in hazard education programs. The data suggest a need for analysis of how their pre-existing beliefs and expectations impinge on information received (e.g. transfer of responsibility). Surprisingly, respondents who participated in a hazard education program or studied lava-flow hazards in school did not show improved awareness of the most recent eruptions or the velocity with which lava flows can travel compared to those who had not participated in education programs and did not study lava flows in school. Perhaps the information provided may not have focused on Kona's situation, or it was not retained by the respondents, because exposure has not greatly improved their knowledge or understanding of *their* volcanic hazards. This suggests a need to explore the content of education programs received prior to the 9th grade and their effects on improving awareness and understanding.

Within the Kona hazardscape, volcanic hazards are given a low priority by residents. Knowledge of the lava hazard zones is at a very low level. Lava flows and ash fall were perceived to be the least two hazards that are likely to affect the respondents' community within the next 10 years. This is potentially problematic given the volcanoes' potential for sudden onset and long duration.

On average, direct experience in a *damaging* natural hazard of any type is low and is much lower for volcanic hazards, although experience with vog appears to be much higher. Moreover, very few respondents have relatives who have been affected by a damaging eruption. It is possible that widespread direct exposure to non-damaging lava flows (37%) has fostered the perception that future volcanic eruptions will be similar to those they have witnessed on television or in person (e.g. at Kīlauea) and thus caused a *normalization bias* (Mileti and O'Brien, 1993; Johnston et al., 1999), rendering respondents less attentive to hazard information and less likely to respond to warnings than they might be otherwise.

With these levels of awareness and knowledge, preparedness is predictably at relatively low levels. The broader issue of hazard preparedness (or a lack thereof) is not specific to the volcanic threat. Moreover, individuals suffer from an unrealistic optimism bias. Because respondents also believe that individuals in the community are less responsible than the emergency management officials or agencies, they may be less inclined to attend to hazard information or react to warnings. In other words, the very fact that specific agencies (e.g. scientific, emergency management) disseminate information and advice on preparedness may actually reduce the perceived need for personal preparedness as a consequence of a transfer of responsibility (Mulilis and Duval, 1995; Ballantyne et al., 2000).

There is a need for education programs that target specific groups and identify methods that promote information exchange between students and adults. Media like Volcano Watch are read by the adult population (especially Whites) but not by students. In both cases, questions regarding the meaning and utilization of this source for preparedness should be considered. Identifying primary preferences for accessing volcanic information is an important consideration. Of eight potential sources, only one (television or radio) was stated as being preferred by a majority of respondents. However, this may reflect familiarity rather than an objective assessment of the medium.

3.2. Engineered measures

Engineered measures to mitigate lava-flow hazards are not planned for Kona and are unlikely to be implemented (Hawai'i State Civil Defense, 2002). Nonetheless, if engineered solutions are implemented, but cannot be guaranteed 100% effective, additional outreach is required to counter phenomena (i.e. risk homeostasis) that may increase risk-taking behavior. If engineered solutions are not implemented, then additional community outreach is needed to increase awareness of the uniqueness of the volcanic threat in Kona and to promote adoption of realistic preparedness and response measures that will foster resilience in future eruptions.

3.3. Adult versus student

We chose to focus on the contrast between student and adult populations, because there is a growing tendency for hazard education programs to target children. This appears to be based on the ease with which children can be approached in large numbers (e.g. in school settings) but also on an assumption that children will later share the information with family members, and those with neighbors, and so on. This assumption needs validating. Our data show that student and adult perceptions differ markedly in many instances.

Our data show that students have received more hazard education in general, as well as specific to volcanic hazards, yet students show lower awareness of the most recent activity of their neighboring volcanoes and the fact that those volcanoes could erupt again. Moreover, fewer students reported that volcanic information was consistent, and a greater number were uncertain about the consistency of the volcanic information. However, despite this, students were more likely than adults (by a factor of 1.7) to perceive that a lava flow could affect their community within the next 10 years.

As anticipated, experience in hazardous events is directly related to age. Surprisingly though, adults consistently indicated that their family had taken more household preparedness measures for frequent emergencies, whereas students reported higher levels of more involved measures such as those needed for more infrequently occurring hazards. This is an interesting inconsistency that requires further analysis to better understand.

3.4. North Kona versus South Kona

Perceptions of past and future volcanic activity are linked to proximity to the hazard source, especially among students. For example, students from each school district are more knowledgeable of, and perceive a greater threat from, the volcano on which they attend school and presumably live. Similarly, parents from each school are more knowledgeable of the recent volcanic activity at this volcano. Parents from both schools perceive Mauna Loa and Hualālai as the two volcanoes most likely to erupt next, although Hualālai is perceived to be less likely to erupt by South Kona parents compared to North Kona parents. A greater percentage of parents from South Kona (one-third) perceive damaging lava flows within the next 10 years as opposed to North Kona parents (11.5%). This time frame may reduce the perceived urgency to prepare. A similar, but less pronounced difference was observed between the students from these districts and together suggests a greater perception of threat from future lava flows in the area of higher hazard (i.e. Mauna Loa in South Kona). Overall awareness of the most recent lava flows at both volcanoes remains low. Nonetheless, awareness of the most recent activity is greater for Hualālai than for Mauna Loa in both North and South Kona, and may be a reflection of the greater salience of Hualālai as a volcano or recent outreach efforts such as USGS's Volcano Watch to increase public awareness of Hualālai as a volcano in repose that will likely erupt again.

3.5. Influence of ethnicity

Ethnicity was found to influence the beliefs about whom or what controls volcanic eruptions, perceptions of future volcanism in Kona, the extent to which respondents have received hazard education, and perceptions of who is responsible for preparing communities for future eruptions and preparedness.

Our data suggest that belief in Pele as the sole controlling factor of Hawaiian eruptions is low in Kona overall, ranging between 20% and 44% for people of Part Hawaiian, Filipino, Hawaiian, and

Spanish ethnicities, respectively; whereas such beliefs were below 13% for other ethnicities. In contrast, belief in pressure alone as the controlling factor was shared by a majority to 71% of people of Hispanic (not Spanish or Portuguese), Japanese, and White ethnicities. A modern study of Hawaiian culture and spiritual beliefs regarding volcanism and its influence on decision making, preparedness, and mitigation is long overdue.

We found that Whites are more aware of the volcanic threat from Hualālai and Mauna Loa than are respondents of other ethnicities. However, a minority of Whites (41.8%) indicated they had participated in a hazard education program, compared to 57% of other ethnicities, and suggests that factors other than involvement in hazard education programs influence awareness and perceptions of volcanic activity. Pacific Islanders (excluding Hawaiian) were much more likely than other ethnicities to perceive USGS as the party responsible for preparing the community for future eruptions (94% compared to 64% for other ethnicities) and less than half as likely to perceive responsibility to lie with individuals (24% compared to 55% for other ethnicities). Similarly, Japanese respondents (95%) were more likely than other ethnicities (82%) to attribute responsibility for community preparedness for volcanic eruptions to Civil Defense. These observations highlight the importance of examining how cultural and ethnic factors influence interaction with hazard issues and agencies. We infer that these individuals have transferred responsibility for preparedness to the authorities and that these groups may be less inclined to attend to information and respond to warnings. Filipino, Spanish, and Japanese Americans were much less likely to perceive Mauna Loa as a volcano that could erupt than were other ethnicities and so may be less likely to make preparations for future eruptions. Portuguese and Spanish respondents (80% and 73%) were found to have participated in hazard education programs much more than other ethnicities (about 50%), yet Spanish respondents showed lower awareness of the volcanic threat from Mauna Loa. Finally, only 21% of Japanese respondents were aware of Volcano Watch compared to 43% of other ethnicities, suggesting that information contained in Volcano Watch is less likely to be disseminated within the Japanese community. Together these data suggest that awareness of the volcanic threat in Kona varies significantly among ethnic groups, but that participation in hazard education programs is not a prerequisite for awareness. The data also suggest some deficiencies in the content of hazard educational material, the ability for respondents to recall information, or widespread dissemination and acceptance of educational material. Education initiatives that are tailored to meet the needs of specific parts of communities are needed. In other words, the blanket provision of the same information is unlikely to be effective and its failure to accommodate specific needs may engender a sense of mistrust in the agencies providing information.

4. Conclusions

At Kona (and throughout the Big Island) awareness of volcanism is extremely high, but this general awareness has not translated into knowledge of the specific future threat to Kona communities. The low levels of individual preparedness for volcanic eruptions in Kona is consistent with both the low to moderate knowledge of the threat posed by Mauna Loa and Hualālai and the findings of others that, historically, few adjustments for lava-flow hazards have been made in Hawai'i. Kates (1971) discussed the low levels of preparedness that can be expected in communities where the frequency of a hazard is low.

The greater frequency of eruptions from Mauna Loa in South Kona suggests a need to improve community preparedness for volcanic eruptions there; but a greater number and density of people and infrastructure occur downslope of potential eruptive sources in North Kona. The majority of respondents are not likely to make plans for an eruption, as they do not believe an eruption will occur. Furthermore, even for those who believe an eruption could or is likely to occur, there is no indication that this perception has translated into increased preparedness such as having a response plan. This reflects the anticipated timing of hazard activity and speed of onset

– these combine to reduce the perceived urgency about preparedness. An expectation is that a long warning period will provide sufficient time for preparation (i.e. between onset of activity and it reaching them). Such perceptions may be difficult obstacles in encouraging new ways of adjusting to the volcanic threat in Kona. One thing is clear though: current community understanding and preparedness on Hualālai, and particularly Mauna Loa falls short of that required for a volcanic crisis, particularly for those eruptions with short onset and high effusion rates on steep slopes that would impact Kona in just a few hours (and some sparsely inhabited areas in less time than that). Misconceptions about potential future eruptions from these volcanoes, and realistic times for lava flows to reach developed areas, contribute to perceptions of low risk and need to be corrected. Scientific and technical knowledge in itself is likely to be ineffective as a means of facilitating preparedness. This is not to say that it should not be provided. Indeed it should. However, it is vitally important, firstly, to identify and correct gaps or misconceptions in people's knowledge. Secondly, information should be presented in a manner that is consistent with the needs and expectations of the community and in a way that is (1) consistent with the reasoning processes involved in rendering information meaningful and (2) readily used in preparedness actions. Our advanced knowledge of the physics of volcanic eruptions must be integrated with understanding how community members differ in regard to how they obtain, process, and utilize information. This is vital in the process of promoting and sustaining community resilience and the ability of individuals to adapt to the consequences of future eruptions in Kona.

These findings can be used to focus future hazard education initiatives or surveys. Education initiatives that promote general hazard awareness and focus on the situation and needs at county or state level are only the first steps in building community resilience to natural hazards. Initiatives are needed now that focus specifically on Kona, its environment and the characteristics of its constituent groups. The high reports of damage from vog may be effective starting points for future education programs, because Paton et al. (2001a) found that people are more likely to listen to hazard-related information and make adjustments to behavior when the information has an immediate effect on their livelihood or well-being. Future hazard education initiatives must also evaluate the changes in threat knowledge, risk perception, and preparedness as a result of exposure to the educational material. Achieving resilience requires that attention is directed towards the nature of the relationship between scientific and emergency management agencies and communities, with the emphasis on community development and empowerment (Paton, 2000). A valid question in Kona and elsewhere on the island is how can we persuade society to make the adaptations needed for both long- and short-duration eruptions from sites other than the currently active Kīlauea east rift zone. This calls for strategies that involve more than just the provision of factual information (Paton, 2000). Creating a realistic understanding of the likelihood of future eruptions is an important starting point to facilitate this shift of thinking.

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