WASHINGTON HOUSEHOLDS' EXPECTED RESPONSES TO THE VOLCANIC THREAT OF MT. RAINIER

A Dissertation

by

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ABSTRACT

This study examines households' knowledge, attitudes and adjustments toward volcanic threat through an investigation of the population at risk from Mt. Rainier. To bridge the gaps of previous volcano research, I first explored the effects of demographic variables, locational variables (i.e., crater proximity, lahar zone location and community bondedness), and past information search on three sets of psychological variables—risk perception, hazard intrusiveness, and affective response. In turn, I examined the effects of these psychological variables along with locational and demographic variables on three measures of hazard adjustments—emergency preparedness, future information search, and evacuation preparedness—made by the households.

The analysis of variance (ANOVA) results show that there were significantly mean differences in five variables—risk perception, hazard intrusiveness, affective response, evacuation plan effectiveness, and community bondedness—among nine communities; however, no significant differences were found in the other four variables—future information search, adequacy of official lahar evacuation routes, school evacuation plan compliance, and adequate preparedness. In addition, the results of ordinary least squares (OLS) regression analyses indicate that two psychological factors (e.g., risk perception and hazard intrusiveness), two demographic factors (e.g., female gender and income), community bondedness, past information search, and hazard proximity (e.g., lahar zone location and crater proximity), all had significant effects on the three measures of hazard adjustments—emergency preparedness, future information

search, and evacuation preparedness.

The findings also reveal that most respondents had low levels of hazard intrusiveness and few engaged in volcano-specific emergency preparedness actions. This makes it essential for local emergency managers to increase residents' volcano hazard awareness and preparedness. Due to the report of high percent of car usage (74.3%) and an increasing population growth in the Puyallup River valley, the local emergency managers should collaborate with transportation engineers to conduct evacuation analyses to determine if the evacuation routes have adequate capacity for the likely evacuation demand. They should also work with land use planners to conduct land use analyses to manage residential and commercial development, as well as the siting of essential facilities such as schools and hospitals.

DEDICATION

To all of my beloved family members:

Wife, Li-Ying Chuang

Beautiful baby girl, Chloe Wei

Parents, Ying-Chung Wei and Shao-Yao Wei-Hsieh

Brother, Hung-Ta Wei

Sister, Jiun-Fei Wei

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NOMENCLATURE

AdeqPrep	Adequate Emergency Preparedness
Affect	Affective Response
ANOVA	Analysis of Variance
ComBond	Community Bondedness
ComPrep	Community Emergency Preparedness
CProximity	Crater Proximity
α	Cronbach's Alpha
EmergPrep	Emergency Preparedness
EvaPrep	Evacuation Preparedness
ExEvDest	Expected Evacuation Destination
ExEvMode	Expected Evacuation Transportation Mode
ExEvRte	Expected Evacuation Route
FutureInfo	Future Information Search
GCS	Geographic Coordinate System
GIS	Geographic Information Systems
HazInt	Hazard Intrusiveness
HomOwn	Homeownership
HousePrep	Household Emergency Preparedness
LZLocation	Lahar Zone Location
M	Mean

NAD	North American Datum
ns	Not Significant
N	Observation Number
OLS	Ordinary Least Squares
PastInfo	Past Information Search
r	Pearson Correlation Coefficient
p	Probability
PADM	Protective Action Decision Model
b	Unstandardized Regression Coefficient
β	Standardized Regression Coefficient
RH	Research Hypothesis
RQ	Research Question
RiskPer	Risk Perception
SD	Standard Deviation
SE	Standard Error
USGS	U.S. Geological Survey

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1. INTRODUCTION

In the past decades, volcanic activity (e.g., explosive eruptions, pyroclastic flows, lava flows, lahars, ash fall, gases, and acid rain) has caused enormous casualties and economic losses worldwide. The 491 volcanic eruptions in the 20th century have produced massive impacts on mortality, morbidity, homelessness, economic collapse, and destruction of both the human-built and natural environments (Witham, 2005). Thus, it is important to understand how people respond to the volcanic threat in order to mitigate volcanic hazard, ensure people's safety, and protect their property from damage.

The importance of volcano research is underscored by a number of international scholars who have examined volcano risk perception or the extent of hazard adjustment adoption or both (Barberi et al., 2008; Carlino et al., 2008; Davis et al., 2006; Finnis et al., 2010; Gaillard, 2008; Gavilanes-Ruiz et al., 2009; Gregg et al., 2004a, 2004b; Haynes et al., 2008; Jóhannesdóttir & Gísladóttir, 2010; Johnston et al., 1999; Paton et al., 2000; Paton et al., 2008; Perry, 1990; Perry et al., 1982; Perry & Greene, 1983; Perry & Lindell, 1990; Perry & Lindell, 2008; Sagala et al., 2009). In addition, other researchers have studied risk communication (Barberi et al., 2008; Bird et al., 2009; Carlino et al., 2008; Dominey-Howesa & Minos-Minopoulos, 2004; Haynes et al., 2008) and evacuation (Barberi et al., 2008; Bird et al., 2009; Carlino et al., 2008; Chenet et al., 2014; Davis et al., 2006; Dominey-Howesa & Minos-Minopoulos, 2004; Gregg et al., 2004b; Jóhannesdóttir & Gísladóttir, 2010; Marrero et al., 2013; Mei et al., 2013; Tobin

& Whiteford, 2002; Woo, 2008). Unfortunately, few volcano studies have explored the joint effects of risk perception, hazard adjustment, risk communication, evacuation, and other relevant variables (e.g., hazard intrusiveness, hazard proximity, affective responses to future volcanic eruption, and community bondedness). To bridge the gaps of previous volcano research, I first examine the effects of demographic variables, locational variables (i.e., crater proximity, lahar crater proximity and community bondedness), and past information search on three sets of psychological variables—risk perception, hazard intrusiveness, and affective response. Subsequently, I investigate the effects of these psychological variables along with locational and demographic variables on three sets of hazard adjustment variables—emergency preparedness, future information search, and evacuation preparedness—made by the households.

This dissertation is structured in the following sections. Section 2 provides a brief review of previous research on risk perception, hazard intrusiveness, affective responses to future volcanic eruption, hazard adjustment, risk communication, evacuation, community bondedness, and hazard proximity that leads to one research question and seven research hypotheses. Section 3 explains the procedures of data collection, survey instrument, Geographic Information Systems (GIS) data management, and analytical approaches employed in this study. Section 4 describes the demographic characteristics of respondents, mean differences in variables among nine communities, and results of factor, scale, zero-order correlation and OLS regression analyses. Section 5 summarizes the major research findings and also discusses the study's limitations, as well as its practical implications.

2. LITERATURE REVIEW

2.1 Risk Perception

Lindell et al. (2006) defined the term risk in terms of the "likelihood that an event of a given magnitude will occur at a given location within a given time period and … the expected consequences that the event will inflict on persons, property, and social functioning" (p. 84). Lindell and Perry (2004) conceptualized risk perception as "certainty, severity, and immediacy of disaster impacts to the individual, such as death, property destruction and disruption of work and normal routines" (p. 127). More recently, Paton et al. (2008) described volcano risk perception as "how people estimate the probability of volcanic hazard activity occurring, and how they interpret this likelihood information" (p. 179). The concept of risk perception is very important because it allows us to investigate how people prepare for and respond to environmental hazards (Peacock et al., 2005; Perry & Lindell, 2008). Perception of personal risk can be measured in terms of expected property damage, casualties, job disruption, and service disruption (Huang et al., 2012; Lindell & Perry, 2004; Lindell & Prater, 2008; Perry et al., 1982; Perry & Lindell, 2008; Showalter, 1993; Wei et al., 2014).

Fitzpatrick and Mileti (1991) asserted that the public's risk perceptions can be affected by several information-specific and public factors. These information-specific factors include source, consistency, accuracy, clarity, certainty, sufficiency, guidance, frequency, specificity, and channel. The public factors are categorized as environmental cues, social setting, social ties, social structure, psychological factors, and pre-warning perceptions. In addition, Fitzpatrick and Mileti (1991) emphasized that "frequently delivered, clear, understandable, and unambiguous, information can significantly enhance the problem-solving agenda embedded within the process of forming perceptions about risk" (p. 147).

Based on previous research in public perception and response to risk information, Mileti and O'Brien (1992) concluded that public response to communicated risk information is a "direct consequence of perceived risk (understanding, belief and personalization), the warning information received (specificity, consistency, certainty, accuracy, clarity, channel, frequency source and so on), and personal characteristics of the warning recipient (demographics, knowledge, experience, resources, social network, cognitions and so on); and perceived risk is a direct function of both the warning information received and the personal characteristics of the warning recipient" (pp. 42-43). Mileti and O'Brien's (1992) results revealed that the perception of aftershock risk was positively correlated with the quality and reinforcement of warning information. However, they found that aftershock risk perception was negatively correlated with age, white ethnicity, and male gender.

Mileti and Peek (2000) emphasized that formation of a risk perception is not a solitary event resulting from a single communication; instead it is considered as a sequential process that people—hear, perceive (understand, believe, and personalize), and finally respond (decide about alternative protective actions and perform them) to the risk information. They also noted that the public's perceptions of risk can be significantly influenced by false alarms, the ways of warning message being disseminated, and the characteristics of authorities' warning messages.

In recent decades, volcano researchers have attempted to understand people's perceived risk with respect to volcanic hazards during volcanic crises or quiescence periods (Davis et al., 2006; Dominey-Howes & Minos-Minopolous, 2004; Gregg et al., 2004a, 2004b; Johnston & Houghton, 1995; Johnston et al., 1999; Kartez, 1982; Perry, 1990; Yosii, 1992). Indeed, volcanic eruptions are generally less common in comparison with other natural hazards (e.g., earthquakes, tornadoes, wildfires, landslides, hurricanes, floods, storm surge, and tsunami). Thus, in most cases people have less experience with such events, resulting in a low level of risk perception (Johnston & Ronan, 2000).

2.2 Hazard Intrusiveness

Perry and Lindell (1990) applied the term "hazard salience" to measure people's frequency of thoughts about the volcanic threat, and found it was positively related to the adoption of hazard adjustment. Barberi et al. (2008) also assessed hazard salience by asking residents how often they think about the possibility of a volcano eruption, based on a 5 point scale. Barberi et al.'s (2008) findings suggested that there were relatively low levels of hazard salience (M = 2.26, SD = .97). This outcome is consistent with a recent volcano study of Ricci et al. (2013), indicating relatively low levels of salience regarding volcanic threat (M = 2.47, SD = 1.09; also on a 5 point scale). This is not surprising, given that volcanic eruptions are less common than other natural hazards.

Lindell and Prater (2000) used the term "hazard intrusiveness" to distinguish this concept from measures of hazard salience and applied it by measuring the extent to which people think about, discuss, and receive information about a hazard. Subsequently, Lindell and Perry (2004) defined hazard intrusiveness as "thoughts generated by the distinctive hazard relevant associations that people have with everyday events, informal hazard-relevant discussions with peers, and hazard-relevant information received passively from the media" (p. 125). Lindell and Prater (2000) believed that assessing risk area residents' frequency of thought and discussion about a hazard could provide an important supplement to assessments of people's judgments of the probability of a major event. They found that hazard intrusiveness was more strongly correlated with hazard adjustment than other variables such as risk perception, disaster experience, and demographic characteristics. Similarly, Ge et al. (2011) documented that hazard intrusiveness was significantly and positively correlated with the mitigation incentive expectations and risk perception.

Regarding people's frequency of thoughts and discussions about environmental hazards, Lindell (1994) found that local residents thought and discussed a chlorine tank car derailment in their community significantly less frequently than an eruption of Mt. St. Helens (40 miles east) or an accident at the Trojan nuclear power plant (less than 10 miles southeast). About 40% of respondents reported thinking about Mt. St. Helens monthly or more frequently, followed by a Trojan nuclear power plant accident (30%) and a chlorine tank car accident (20%). Moreover, approximately 18% of respondents reported discussing about Mt. St. Helens monthly or more frequently, followed by the Trojan nuclear power plant (15%) and a chlorine accident (10%). In their examination of hazard intrusiveness, Davis et al. (2006) asked residents how often they think about and talk about lahars; their results showed that it is only a few times a year that many respondents think (36.5%, $N = 94$) and talk (42.6%, $N = 106$) about this hazard.

Hazard intrusiveness is very similar to the terms of “rumination” and “preoccupation” that are used in the clinical literature to refer to extremely repetitive thoughts that seem to be highly distressing and have adverse psychological outcomes for an individual. However, hazard intrusiveness refers to repetitive thoughts that are only mildly distressing and are likely to lead to protective action. Nolen-Hoeksema et al. (2008) defined rumination as “the process of thinking perseveratively about one’s feelings and problems rather than in terms of the specific content of thoughts” (p. 400). Based on previous literature, Nolen-Hoeksema et al. (2008) concluded that rumination is related to depression, anxiety, binge eating, binge drinking, self-harm, dysfunctional attitudes, hopelessness, pessimism, self-criticism, low mastery, dependency, sociotropy, neediness, and neuroticism. Moreover, their evidence showed that rumination exacerbates depression, enhances negative thinking, impairs problem solving, interferes with instrumental behavior, and erodes social support. In another rumination study, Whitmer and Gotlib (2013) defined rumination as “repetitive thinking about negative personal concerns and/or about the implications, causes, and meanings of a negative mood” (p. 1036), and it has been found to cause serious maladaptive consequences, including longer and more severe episodes of major depression. By using an attentional scope model of rumination, Whitmer and Gotlib (2013) found that at a cognitive level, rumination is more likely to arise when people are in a negative mood state. Likewise, Koster et al. (2014) argued that rumination is a problematic self-regulation strategy that is related to negative consequences on mood and cognition.

Researchers have distinguished self-preoccupation from external-preoccupation. Sakamoto (1998) defined self-preoccupation as “the tendency to focus more on the self than on others or one’s environment and to maintain self-focused attention” and external-preoccupation as “the tendency to maintain external-focus on a specific object” (p. 646). Kielholz (1972) suggested that both self-preoccupation and external-preoccupation were associated with depression. However, Sakamoto’s (1998) research found that only self-preoccupation was significantly correlated with depression. To measure the preoccupation with tornadoes, Weinstein et al. (2000) used items measuring vigilance, frequency of thoughts, and intrusive thoughts. Their findings suggested that preoccupation was the best predictor of precaution adoption and the three separate items (vigilance, frequency of thoughts, and intrusive thoughts) were equally related to action. In addition, Weinstein et al. (2000) found that the odds that people moderately high on preoccupation with tornadoes would take action were 56% to 79% greater than those of people moderately low on preoccupation.

2.3 Affective Responses to a Future Volcanic Eruption

Slovic and his colleagues (e.g., Slovic et al., 2007; Slovic & Peters, 2006) have proposed that there is an “affect heuristic” that is distinct from “analytic” risk perceptions. Slovic and Peters (2006) defined the term “affect heuristic” as “reliance on risk as feelings” (p. 322) and reported that the feeling of dread was the dominating factor of public perception and acceptance of risk for a wide range of hazards. Similarly, Slovic et al. (2007) found that risk perceptions and society's responses to risk were strongly linked to the degree to which a hazard evoked feelings of dread. The finding of Slovic and Peters (2006) suggested that affect has direct and indirect influences on risk perceptions when mixed responses of anger and fear exist. Consistent with the "affect heuristic", Terpstra (2011) discovered that negative feelings were associated with increased flood risk perceptions while positive feelings had the opposite effect. More recently, Lindell et al. (in press) found that risk perception was significantly correlated with some affective responses—shock (r = .36) and fear (r = .48). However, other risk researchers have raised questions about the relationship between affect and risk perception (see the discussions in Lindell, 2014; Sjöberg, 2006; Wardman, 2006).

In another volcano study, Carlino et al. (2008) asked respondents to indicate how they felt about the likelihood of future eruptions at Vesuvius. The results showed that respondents felt panic (42%), followed by an inability to act (21%), anxiety (18%), fear (10%) and indifference (4%). Regarding a case study of Volcán de Colima, Mexico, Gavilanes-Ruiz et al. (2009) concluded that a majority of respondents in La Yerbabuena feared the volcano (42%); however, only 8% of respondents in Cofradia de Tonila expressed this affective response. More recently, Ricci et al. (2013) asked respondents to rate how much they worry about a potential eruption based on a 5 point Likert scale. Their results showed a moderately high level of worrying about a potential eruption (M = 3.42, SD = 1.15), which is consistent with Barberi et al.'s (2008) finding (M = 3.8, SD = 1.15).

2.4 Hazard Adjustment

White and Haas (1975) described hazard adjustment as “all those intentional actions which are taken to cope with the risk and uncertainty of natural events” (p. 57). Similarly, other disaster researchers have argued that hazard adjustment can be conceptualized as a set of instrumental responses or protective actions that people have undertaken to reduce their vulnerability to disaster impacts (Baisden & Quarantelli, 1979; Burton et al., 1978; Mileti, 1980). Gregg (2004b) defined adjustment adoption as “how people cope with, prepare for, respond to, or otherwise live with specific hazards” (p. 533). Perry and Lindell (2007) mentioned that the “adoption of mitigation and preparedness is part of a broader process called hazard adjustment” (p. 336). Sagala et al. (2009) defined household preparedness as “all types of activities carried out to enhance the ability of social units to respond when a disaster occurs” (p. 47). More recently, Finnis et al. (2010) identified preparedness activities such as having family plans, practicing in home- and school-based emergency practices, and adopting specific household hazard adjustments. The importance of disaster preparedness at community and personal levels was also emphasized in the Hyogo Framework for disaster reduction (ISDR, 2005).

Some protective actions, such first aid kits and flashlights, are suitable for many different kinds of hazards. However, other protective actions are hazard-specific—as, for example, masks for inhalation protection that are most useful for volcanic ash and sometimes for hazardous chemicals or other particulates (Perry & Lindell, 2008). In terms of volcano adjustments, preparedness items or protective actions can be measured by purchase of volcano insurance; knowledge about the local alert system; storing devices for breathing protection; reinforcing structures against weight/water; defensive tools (e.g., hoses, nozzles, shovels, and brushes/brooms); and having a complete evacuation plan that includes a safe route of travel and evacuation destination (Perry & Lindell, 2008).

Most hazard studies have demonstrated a significant association between hazard adjustment and risk perception—including studies of earthquakes (Lindell & Perry, 2000), hurricanes and other storms (Peacock, 2003; Preston et al., 1983), and volcanic eruptions (Johnston et al., 1999; Perry & Lindell, 1990). However, other hazard research indicated that risk perception is not strongly related to hazard adjustment (Lindell & Whitney, 2000; Paton et al., 2000; Weinstein & Nicolich, 1993). Likewise, Perry and Lindell's (2008) study of multi-hazard environment reported that risk perception was not a statistically significant predictor of a number of adjustments for the three hazards (e.g., wildfires, earthquakes and volcanic activity). Even if people are living in high risk areas, they are most likely to have low levels of protective measures. For example, Lindell and Prater (2000) concluded "[t]he level of [hazard adjustment] adoption does not appear to be high even after decades of major California earthquakes" (p. 317). In addition, Gregg et al. (2004a) demonstrated that citizens exposed to volcanic hazards in Hawaii had undertaken few protections.

2.5 Risk Communication

A major purpose of environmental risk communication is to promote household adoption of hazard adjustments (Lindell et al., 2006). Similarly, Paton et al. (2008) argued that a key goal of risk communication is to encourage people to adopt preparedness measures that can reduce their vulnerability and handle hazard consequences. For most environmental hazards, the risk communication process should allow all stakeholders to share information about hazards affecting a community, and this process should focus on the hazard analysis (e.g., assessment of hazard recurrence intervals and identification of risk areas) and vulnerability analysis (assessment of the susceptibility of people and animals to injury or death, and of structures to damage or destruction, see Perry & Lindell, 2007). Unfortunately, during the 1985 eruption of Nevado del Ruiz in Colombia more than 20,000 people were killed by lahars due to the lack of a warning system and insufficient communication among emergency responders, scientists, and the local communities, leading to a failure of the warning dissemination and evacuation (Johnston & Ronan, 2000). As Lindell et al. (2006) noted, risk communication programs should ensure that people are aware of the available hazard adjustments and have accurate beliefs about the efficacy and resource requirements of these hazard adjustments.

Griffin et al. (1999) proposed a model of risk information seeking and processing and concluded that people's risk information seeking behavior in both routine and non-routine channels can be influenced by seven factors—individual characteristics; perceived hazard characteristics; affective response to the risk; felt social pressures to possess relevant information; information sufficiency; one's personal capacity to learn; and briefs about the usefulness of information in various channels.

Lindell and Whitney (2000) asserted that the probability of hazard adjustment adoption is higher if messages address attitudes toward the hazard adjustments themselves as well as addressing the hazard. In turn, as Lindell and Perry (2004) pointed out, people who seek information will be more likely to be motivated to prepare. Perry and Lindell (2008) noted that information seeking is "the conceptual portal to knowledge of the hazard, its consequences, the availability and effectiveness of protective measures and implementation procedures" (p. 175). More recently, Lindell (2014) reported that some studies have shown "uncertainty about a threat was associated with intentions to seek further information whereas uncertainty about the efficacy of the protective action was associated with intentions to avoid further information" (p. 412).

Previous studies on earthquakes and volcano activity have found that information seeking behavior was significantly associated with risk perception and hazard adjustment (Johnston et al., 1999; Mileti & Darlington, 1997; Mileti & Fitzpatrick, 1992; Perry & Lindell, 1990; Perry & Lindell, 2008). On the other hand, older residents and those with higher levels of education have been shown to be less confident in their own preparedness and the success of the evacuation plan, and less satisfied with the amount of information they had about the volcanic threat (Barberi et al., 2008).

2.6 Evacuation

Evacuation is the most common protective action in response to a warning (Sorensen, 2000). The objective of evacuation is to remove people from impact areas (Lindell & Perry, 1992) and it is considered as to be the most effective way to avoid casualties from lava flows (Gregg, 2004b). Lindell et al. (2011) defined evacuation logistics as "the activities and associated resources needed to reach a safe location and remain there until it is safe to return" (p. 1093). Furthermore, Lindell et al. (2011) addressed evacuation issues such as when people evacuated, how many vehicles they took, which routes they travelled, where they went, what accommodations they used, how many days they were gone, and how much the evacuation cost (see also Kang et al. 2007; Wu et al. 2012, 2013).

In the Hurricane Lili evacuation study, Kang et al. (2007) documented that household hurricane evacuation involves a number of preparatory activities (e.g., installing window shutters, packing bags, gathering the family) and choosing a mode of transportation, route of travel, and evacuation destination. It is very important to examine people's evacuation behavior (e.g., expected choice of evacuation destination, evacuation transportation mode, and evacuation route); however, Kang et al. (2007) indicated that "there are no theoretical grounds for making specific predictions about the degree to which expectations at one point in time (i.e., during a survey) will be confirmed years later during a hurricane evacuation" (p. 890). During the Hurricane Lili evacuation, Kang et al. (2007) found that 22 of 25 (88.0%) respondents actually took their own cars for evacuation, and 2 of 3 (66.7%) respondents rode with someone else, but no one in this sample used the public transportation. On the other hand, Perry et al. (1981) found that 74% of evacuees used their own vehicles during flood evacuations and 13% of them either rode with relatives or friends or took public transportation. In terms of vehicle usage, Kang et al. (2007) found that respondents took an average of 1.62

vehicles per household during evacuation, and this result was consistent with other disaster studies that households generally took more than one car when evacuating (Dash & Morrow, 2001; Dow & Cutter, 2002; Lindell et al., 2011; Siebeneck & Cova, 2008; Wu et al., 2012; Wu et al., 2013).

In the Hurricane Ike evacuation study, Wu et al. (2013) indicated that most of the evacuees stayed with their friends or relatives (63%), but some stayed in hotels or motels (26%), and—consistent with Mileti et al. (1992)—only a few stayed in public shelter (less than 1%). In addition, they found that evacuees took more vehicles during Ike evacuation if they were younger (r = -.20), married (r = .15), had a bigger household (r = .28), had a higher income (r = .31), or had more registered vehicles (r =.45).

In Barberi et al.'s (2008) volcano evacuation study, 55% of respondents said they were not familiar with their community's evacuation/emergency plan, and of those who were aware of the plan, about 50% could not correctly identify the place to be evacuated. These results indicate a lack of collaboration between the emergency managers and the public. In addition, the low levels of confidence in the evacuation plan suggested that citizens knew few details of the plan and had no idea what to do when an evacuation order is issued (Barberi et al., 2008).

Carlino et al. (2008) proposed that a successful evacuation depends upon four main components: "cooperation between officials, scientific authorities, and at-risk populations; risk education of at-risk populations; high-quality evacuation facilities; and assistance provided by other regions and countries" (p. 241). During a volcanic crisis at Soufrière Hills about 10,000 people were successfully evacuated (Druitt & Kokelaar, 2002). However, a large or high density of population involved in the evacuation in the event of an eruption could be a big challenge. For example, the evacuation process can be logistically complex, and the economic burden of evacuation is great for people who live near volcanoes that are located near densely populated regions (Woo, 2008). As Mei et al. (2013) noted, evacuation refusals at Merapi volcano and Mt. St. Helens showed that local communities were prepared to face the eruption, but not all members of the communities at risk were prepared to evacuate and given a choice, some individuals will not leave. Mei et al. (2013) also argued that evacuation management should not only focus on moving people from a threatened area to a safer area, but also taking care of their livelihoods before, during, and after the crisis.

Chenet et al. (2014) pointed out a successful evacuation of a volcano risk area could happen only if people realize that the evacuation should not be spontaneous, but instead follow a well-managed evacuation plan. However, managing an orderly evacuation is a challenging task because hurricane evacuation studies have demonstrated that very few evacuees depend on written materials received or recommendations from local officials or the news media before and during an event. Instead, they are more likely to rely on personal familiarity with their evacuation routes and on prior expectations about time, safety or convenience (Dow & Cutter 2002; Lindell et al., 2005; Wu et al., 2012; Zhang et al., 2004).

A number of hurricane studies have indicated that evacuation is significantly related to the female gender (Bateman & Edward, 2002; Fothergill, 1996; Gladwin et al., 2001; Huang et al., 2012; Lindell et al., 2005; Riad et al., 1999; Whitehead, 2005;

Whitehead et al., 2000), risk perception (Baker, 1991; Fitzpatrick & Mileti, 1991), and information seeking (Fitzpatrick & Mileti, 1991; Lindell et al., 2005). However, reviews by Baker (1991) and Huang et al. (in press) have concluded that demographic and experience variables have small and inconsistent correlations with evacuation.

2.7 Community Bondedness

In a study of a hazardous waste facility, Bachrach and Zautra (1985) used a 7-item scale to measure the sense of community. These seven items include—feeling at home in the community; satisfaction with the community; agreement with the values and beliefs of the community; feeling of belonging in the community; interest in what goes on in the community; feeling an important part of the community; and attachment to the community. The scale was found to be internally consistent (α = .76). Bachrach and Zautra's (1985) results showed that the sense of community was significantly correlated with involvement in community organizations (r = .41), and length of residency in the community (r = .26).

Turner et al. (1986) defined community bondedness as neighborhood tenure, identification of the neighborhood as home, participation in community organizations, and the presence of friends and relatives nearby; and they found community bondedness was correlated with preparedness for earthquakes. As Paton et al. (2001) noted, examination of people's sense of community could help understand the prevailing degree of community fragmentation, and consequently the level of support for mitigation strategies involving collective community action. They found that the perceived sense of community significantly increased with levels of support (*r* = 0.32).

Barberi et al.'s (2008) study reported that the mean level of community bondedness was 2.61 (*Low* = 1; *High* = 4) with a standard deviation of 0.37, suggesting residents near the Vesuvius volcano had a moderately strong attachment to their community. Also, the researchers found that community bondedness is positively correlated with some risk perception variables, people's preparedness, preparedness of government officials, confidence in the success of the evacuation plan, and received information about volcanic hazards. Consistent with Barberi et al.'s (2008) results, Ricci et al. (2013) also found a moderately high level of community bondedness for residents near the Vesuvius volcano (*M* = 2.86, *SD* = .48) using the same rating scale (*Low* = 1; *High* = 4). Davis et al. (2006) found similar findings; there was a high level of community bondedness in a Mt. Rainier mail survey (*M* = 2.07) that used a 5 point Likert scale (*Strongly agree* = 1; *Strongly disagree* = 5).

2.8 Hazard Proximity

Through an investigation of the 1980 Mt. St. Helens eruption, Blong (1984) reported that residents near the volcano had a low level of risk perception even though the volcano had relatively large-scale eruptions. Similarly, two other volcano studies found that people who lived near the Volcano Vesuvius lacked high levels of perceived volcanic risk (Barberi et al., 2006; Davis et al., 2005; Dobran, 2006). These results might indicate that people who resided close to volcanoes had low levels of perceived risk due to long periods of quiescence. If so, emergency managers should pay more attention to such low levels of perceived volcanic risk because people are less likely to adopt effectively protective actions due to the lack of risk awareness and perception.

There is considerable evidence that perceived risk is linked to the proximity of natural hazard sources—volcano (Blong, 1984; Gregg et al., 2004a; Johnston et al., 1999), earthquake (Palm et al., 1990), and hurricane (Baker, 1991; Lindell et al., 2005; Lindell & Hwang, 2008; Peacock et al., 2005; Zhang et al., 2010). However, Gavilanes-Ruiz et al. (2009) found that volcano proximity did not directly influence risk perception. Farley et al. (1993) reported that proximity to the New Madrid fault was correlated with hazard adjustment and other studies (Gladwin & Peacock, 1997; Lindell et al., 2005; Wilmot & Mei, 2004) have shown that hazard proximity is related to evacuation.

2.9 Research Question and Hypotheses

Based on the findings and limitations of previous literature, this study will try to identify the relationships among a number of variables that have been found to predict volcano hazard awareness and adjustment. The measures of household hazard adjustment are emergency preparedness, future information search, and evacuation preparedness. The predictors of hazard adjustment are risk perception; hazard intrusiveness; affective responses, hazard proximity; past information search; community bondedness; home ownership; community tenure; and income. The predictors of the psychological variables are hazard proximity, past information search, community bondedness, community tenure, household income, female gender, white ethnicity, education, and age. Finally, the predictor of community bondedness is community tenure. The data will encompass multiple communities in Pierce County, Washington, that vary in their distances from Mt. Rainier.

The research question and hypotheses for this study are as follows:

RQ: Are there mean differences in variables (i.e., risk perception, hazard intrusiveness, affective response, expected future information search, adequacy of official lahar evacuation routes, evacuation plan effectiveness, school evacuation plan compliance, adequate preparedness, and community bondedness) among nine communities?

RH1: Volcano risk perception will be significantly correlated with hazard intrusiveness and affective response.

Risk researchers (e.g., Lindell et al., in press; Slovic et al., 2007; Slovic & Peters, 2006) have found that risk perception is related to affective reactions, particularly when risk perception is measured by perceived personal consequences (Lindell, 1994; Lindell et al., in press; Sjöberg, 2006). These findings provide a rationale for Hypothesis 1. The small amount of existing literature suggests risk perception, hazard intrusiveness, and affective response are highly correlated, so I assume that all three variables have similar relations with other variables.

RH2: Psychological variables (i.e., risk perception, hazard intrusiveness, and affective response) will be positively related to demographic variables of community tenure, female gender, and age, but negatively related to households' income, white ethnicity, and education.

There is some evidence that demographic variables are significantly related to risk perception even though they do not appear to be consistently related to short-term protective actions or long-term hazard adjustment. A number of disaster researchers have found that risk perception measures are correlated with households' demographic characteristics—tenure (Peacock et al., 2005), age (Barberi et al., 2008; Griffin et al., 1999; Hanson et al., 1979; Houts et al., 1984), female gender (Barberi et al., 2008; Fothergill, 1996; Griffin et al., 1999; Lindell & Hwang, 2008; Mileti & O'Brien, 1992; Peacock et al., 2005; Slovic, 2000; Tuner et al., 1986), lower education and income (Fothergill & Peek, 2004; Lindell & Hwang, 2008; Peacock et al., 2005), and ethnic minorities (Adeola, 2000; Fothergill et al., 1999; Hodge et al., 1979; Lindell & Hwang, 2008; Major, 1999; Mileti & O'Brien, 1992; Peacock et al., 2005; Tuner et al., 1986). These findings provide a rationale for Hypothesis 2.

RH3a: Community bondedness will be significantly correlated with community tenure.

RH3b: Community bondedness will be positively correlated with the three psychological variables, and all three components of hazard adjustment—emergency preparedness (i.e., household emergency preparedness, community emergency preparedness, and adequate preparedness), future information search, and evacuation preparedness (i.e. expected evacuation mode, destination and routes, and evacuation plan effectiveness).

Community bondedness was significantly correlated with tenure (length of residency) in the community (Bachrach & Zautra, 1985). Barberi et al.'s (2008) volcano study demonstrated that community bondedness is positively correlated with some risk perception variables, people's preparedness, preparedness of government officials, confidence in the success of the evacuation plan, and received information about volcanic hazards. Turner et al. (1986) suggested that community bondedness was relevant to hazard preparedness, as did Paton et al. (2001). These findings provide a rationale for Hypothesis 3a and 3b.

RH4: Past hazard information search will be significantly correlated with the three psychological variables, and all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness.

Researchers of earthquakes and volcano activity found that information seeking behavior was significantly related to risk perception and hazard adjustment (Johnston et al., 1999; Mileti & Darlington, 1997; Mileti & Fitzpatrick, 1992; Perry & Lindell, 1990; Perry & Lindell, 2008). These findings provide a rationale for Hypothesis 4.

RH5: Hazard proximity (i.e., lahar zone location and crater proximity) will be significantly correlated with the three psychological variables (risk perception, hazard intrusiveness, affective response), and all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness.

A large number of hazard studies reported that perceived risk is associated with the proximity of natural hazard sources—volcano (Blong, 1984; Gregg et al., 2004a; Johnston et al., 1999), earthquake (Palm et al., 1990), and hurricane (Baker, 1991; Lindell et al., 2005; Lindell & Hwang, 2008; Peacock et al., 2005; Zhang et al., 2010). However, Gavilanes-Ruiz et al. (2009) found that volcano proximity did not directly influence risk perception. Farley et al. (1993) noted that the proximity to the New Madrid fault was linked with hazard adjustment. Other studies (Gladwin & Peacock, 1997; Lindell et al., 2005; Wilmot & Mei, 2004) have shown that hazard proximity is related to evacuation. Previous volcano research demonstrated that people who lived near volcanoes had low levels of risk perception (Barberi et al., 2006; Blong, 1984; Davis et al., 2005; Dobran, 2006). These findings provide a rationale for Hypothesis 5.

RH6: Hazard adjustment adoption (i.e., emergency preparedness, future information search, and evacuation preparedness) will be positively correlated with the three psychological variables (risk perception, hazard intrusiveness, affective response), household income, community tenure, and homeownership.

The significant relationships between hazard adjustment and risk perception were found in studies of earthquakes (Lindell & Perry, 2000), hurricanes and other storms (Peacock, 2003; Preston et al., 1983), and volcanic eruptions (Johnston et al., 1999; Perry & Lindell, 1990). However, other hazard research indicated that risk perception is not strongly related to hazard adjustment (Lindell & Whitney, 2000; Paton et al., 2000; Weinstein & Nicolich, 1993). Also, Perry and Lindell's (2008) study of multi-hazard environment reported that risk perception was not a statistically significant predictor of a number of adjustments for the three hazards (e.g., wildfires, earthquakes and volcanic activity). In a seismic study of Lindell and Prater (2000), hazard adjustment was found to be positively correlated with tenure, homeownership, and household income. However, Lindell and Hwang (2008) discovered the correlation between wind adjustment and income was negative. These findings provide a rationale for Hypothesis 6.

RH7: There will be relatively low levels of hazard intrusiveness (i.e. thought and discussion), but this variable will be more strongly correlated with all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness—than the other psychological variables (risk perception and affective response).

In two volcano studies, Barberi et al. (2008) and Ricci et al. (2013) reported that there were relatively low levels of hazard salience (roughly equivalent to the present study's hazard intrusiveness variable) using a 5 point scale, where the mean values were 2.26 and 2.47, respectively. Similarly, Davis et al. (2006) found low percentages of hazard intrusiveness—think about lahars for a few times a year (36.5%, N = 94), and talk about lahar for a few times a year (42.6%, N = 106). Lindell and Prater (2000) discovered that hazard intrusiveness was more strongly correlated with hazard adjustment than other variables such as risk perception, disaster experience, and demographic characteristics. Ge et al. (2011) also found that hazard intrusiveness was stronger than risk perception in predicting expected mitigation incentive participation, although the difference in the correlations was small. These arguments provide a rationale for Hypothesis 7.

I utilize a conceptual model (see Fig. 1) to examine the relationships among variables and test above seven hypotheses.

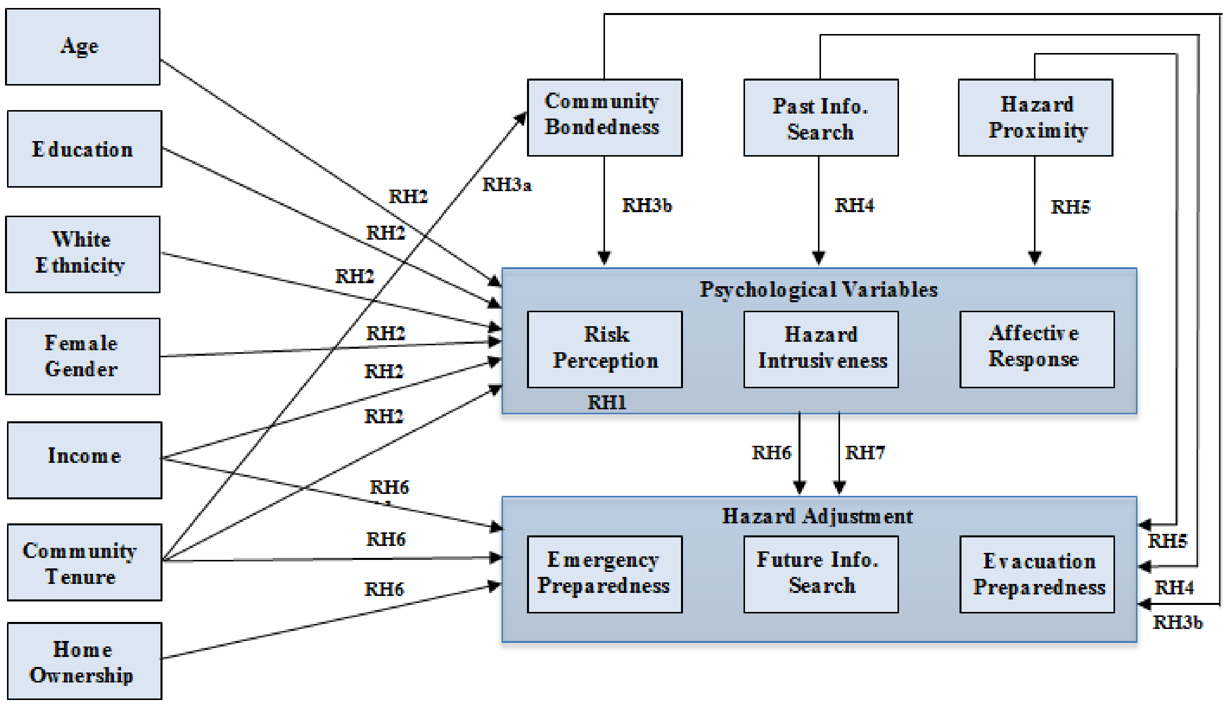

Figure 1 A Conceptual Model for Testing Seven Hypotheses

2.10 Background of Study Area

Mt. Rainier with a summit elevation of 14,410 feet is Washington's tallest volcano; it last erupted in the 19th century (USGS, 2002). The next eruption could produce volcanic ash, lava flows, or pyroclastic flows that threaten the lives and property of more than 150,000 people living on the deposits of previous lahars (USGS, 2002). An eruption of Mt. Rainier will directly affect the people of Pierce County and neighboring counties, disrupt the region's economy, and damage infrastructure (PCEM, 2008). Because of the higher level of risk from lahars in the Carbon and Puyallup River valleys, the U.S. Geological Survey (USGS) and Pierce County Department of Emergency Management have installed a lahar detection and warning system that includes five acoustic flow monitors that will detect a lahar's ground vibrations (USGS, 2002). The Mt. Rainier Lahar Siren system will be utilized to warn the residents in the Puyallup River Valley to evacuate when the imminent volcanic hazard threatens (PCEM, 2015). Moreover, the USGS, local educators, and emergency managers have been involved in a public education program intended to inform residents and visitors about volcanic hazards, evacuation routes, and other appropriate response measures (Johnston et al., 2001).

We selected the nine communities of Carbonado, Wilkeson, Buckley, South Prairie, Orting, Puyallup, Sumner, Pacific, and Tacoma in Pierce County as our study areas because these communities vary in their proximity to the volcano crater (ranging 15-40 miles) but all are vulnerable to moderate lahars (recurrence interval 100–500 years) and large lahars (recurrence interval 500–1000 years) when the Mt. Rainier erupts (see Fig. 2). According to U.S. Census Bureau (2013), the 2013 estimated populations for these nine communities are as follows: South Prairie (435), Wilkeson (484), Carbonado (613), Buckley (4,453), Orting (7,023), Pacific (7,034), Sumner (9,589), Puyallup (38,609), and Tacoma (203,446).

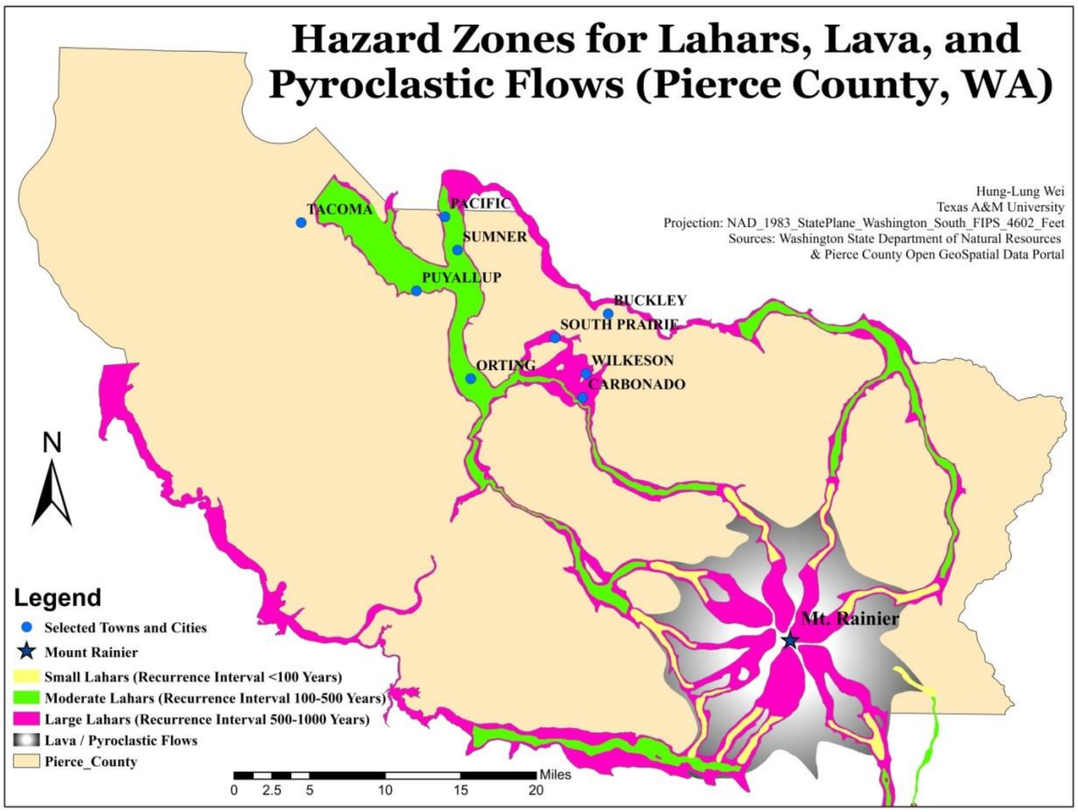

Figure 2 Risk Map for the Study Area

3. METHODS

3.1 Procedure

A disproportionate 1,050 household sample was randomly drawn from the nine communities of Buckley (100), Carbonado (75), Orting (175), Pacific (100), Puyallup (200), South Prairie (50), Sumner (175), Tacoma (100), and Wilkeson (75) in Pierce County, Washington. The University of Washington and Texas A&M University collaboratively conducted a volcano mail survey of households between August and September of 2014. Following Dillman's (2000) *Tailored Design Method*, each household was sent an initial questionnaire and non-respondents were sent a reminder postcard and as many as two replacement questionnaires. This process was terminated when non-respondents had been sent as many as one reminder postcard and three questionnaire packets. Of 1,050 selected households, 83 packets were either undeliverable or were refused; 419 households returned usable questionnaires for a response rate of 43.33%.

3.2 Survey Instrument

As seen in APPENDIX A, the questionnaire was guided by the Protection Action Decision Model (PADM) that provides a theoretical framework for understanding decision making, behavioral response, and preparedness with respect to environmental hazards (Lindell & Perry, 2004; Lindell et al., 2006). Table 1 shows that different variables included in this questionnaire have been utilized by many hazard studies.

Table 1 List of the Scales Measured by Other Sources

Items	Variable	Sources
12	Household Emergency Preparedness	Lindell & Prater, 2000; Perry, 1990; Perry & Lindell, 2008
2	Community Emergency Preparedness	Davis et al., 2006
3	Adequate Preparedness	Davis et al., 2006
3	Future Information Search	Mileti & Darlington, 1997; Mileti & Fitzpatrick, 1992; Mileti & O'Brien, 1992
1	Evacuation Transportation Modes	Davis et al., 2006; Dash & Morrow, 2001; Dow & Cutter, 2002; Kang et al., 2007; Lindell et al., 2011; Siebeneck & Cova, 2008; Wu et al., 2012; Wu et al., 2013
6	Evacuation Destination and Routes	Davis et al., 2006; Kang et al., 2007; Lindell et al., 2011; Siebeneck & Cova, 2008; Wu et al., 2012; Wu et al., 2013
8	Evacuation Plan	Davis et al., 2006
6	Risk Perception	Fitzpatrick & Mileti, 1991; Huang et al., 2012; Huang et al., 2015; Lindell & Prater, 2000; Lindell et al., 2005; Lindell & Whitney, 2000; Mileti & O'Brien, 1992; Mileti & Peek, 2000
8	Hazard Intrusiveness	Davis et al., 2006; Ge et al., 2011; Lindell, 1994; Lindell & Perry, 2004; Lindell & Prater, 2000
12	Affective response	Barberi et al., 2008; Carlino et al., 2008; Gavilanes-Ruiz et al., 2009; Lindell et al., in press; Ricci et al., 2013; Slovic et al., 2007; Slovic & Peters, 2006; Terpstra, 2011
6	Community Bondedness	Bachrach & Zautra, 1985; Barberi et al., 2008; Davis et al., 2006; Paton et al., 2001; Ricci et al., 2013; Turner et al., 1986
3	Past Information Search	Davis et al., 2006; Mileti & Darlington, 1997; Mileti & Fitzpatrick, 1992; Mileti & O'Brien, 1992; Perry & Lindell, 1990; Perry & Lindell, 2008
7	Demographic Variables	Barberi et al., 2008; Fothergill, 1996; Gladwin & Peacock, 1997; Griffin et al., 1999; Lindell et al., 2005; Lindell & Hwang, 2008; Lindell & Perry, 2000; Lindell & Prater, 2000; Lindell & Whitney, 2000; Mileti & O'Brien, 1992; Peacock et al., 2005; Slovic, 2000; Tuner et al., 1986

3.2.1 Emergency Preparedness

Household emergency preparedness, community emergency preparedness, and adequate preparedness were defined as specific indicators of emergency preparedness. For example, respondents were asked to report (*No* = 0; *Yes* = 1) whether they have adopted the following 12 household emergency preparedness items—working transistor radio with spare batteries; at least 4 gallons of water in plastic containers; complete first-aid kit; 4 day supply of dehydrated or canned food for yourself and your family; fire extinguisher; flashlight and batteries; breathing protection for volcanic ash; at least one week supply of prescription medicines; important documents (birth certificates, wills, inventory of household items); cash, credit card, and check book; at least one change of clothing per person; and extra glasses or contact lenses. Household emergency preparedness was computed from the mean response over these twelve items. Regarding community emergency preparedness, respondents were asked to indicate (*No* = 1; *Don't know* = 2; *Yes* = 3) whether they thought their community had the following two preparedness measures—a lahar warning system and a lahar evacuation plan. Community emergency preparedness was computed from the mean response over the two items. In terms of adequate preparedness, respondents rated the extent (*Not at all* = 1 to *Very great extent* = 5) to which each of three groups of stakeholders was prepared for a major Mt. Rainier eruption—themselves and their families; other members of their community; and local officials of their community. Adequate emergency preparedness was computed from the mean response over these three items.

3.2.2 Future Information Search

Expected future information search was measured by a five point rating scale. The expected future information search item asked respondents to judge the likelihood (*Extremely unlikely* = 1 to *Extremely likely* = 5) of seeking three information types—Mt. Rainier eruption risks; community's lahar warning system; and community's lahar evacuation routes. Expected future information search was computed from the mean response over these three items.

3.2.3 Evacuation Preparedness

Evacuation preparedness was defined as measures of expected evacuation mode, destination and routes, and evacuation plan effectiveness. The expected evacuation mode item asked respondents what kind of transportation (*Car* = 1; *Other* = 0) and how many cars will be used for evacuation. The expected evacuation destination item asked respondents to point out (*No* = 0; *Yes* = 1) whether and where they have planned to go when evacuating from home. The expected evacuation routes item asked respondents to report (*No* = 0; *Yes* = 1) whether and which route they have planned to take when evacuating from home. The practiced official evacuation routes item was measured by asking respondents to indicate (*No* = 0; *Yes* = 1) whether they have ever followed their community's official lahar evacuation route(s)—during an official warning; as part of an official training exercise; and motivated by personal curiosity. The adequacy of official lahar evacuation routes item asked respondents to rate the extent (*Not at all* = 1 to *Very great extent* = 5) that the official community evacuation routes provide adequate means of evacuation from a lahar. The evacuation plan effectiveness item asked respondents to judge the likelihood (*Extremely unlikely* = 1 to *Extremely likely* = 5) of three types of consequences—they will receive an official lahar warning; they can prepare to evacuate; and they can evacuate to a safe location—after an eruption begins but before a lahar arrives. Evacuation preparedness was computed from the mean response over these five items—whether, and where respondents have planned to go when evacuating from home, and other three items of evacuation plan effectiveness.

3.2.4 School Evacuation Plans

With respect to school evacuation plans, respondents were asked to identify (*No* = 1; *Don't know* = 2; *Yes* = 3; *Not applicable* = 4) whether their child's school (K-12) has a lahar evacuation plan. The school evacuation plan compliance item asked respondents to report the degree of agreement (*Strongly disagree* = 1 to *Strongly agree* = 5) with three statements—I trust the evacuation plan at my child's school to protect them from lahars; I will allow my child to remain at school when a lahar warning is issued; and I will go and get my child from school when a lahar warning is issued. School evacuation plans was computed from the mean response over these three items.

3.2.5 Risk Perception

Based on a five point scale of *Extremely unlikely* (=1) to *Extremely likely* (=5), risk perception was measured by asking respondents to judge the likelihood of six types of consequences—major damage to their property by lava flows; major damage to their property by lahars (volcanic mudflows); major damage to their property by ash fall; injury or death to themselves or members of their households; disruption to their jobs that would prevent them from working; and disruption to their access to electric, phone, and other basic services—for the volcanic hazard within the next 10 years. Risk perception was computed from the mean response over these six items.

3.2.6 Hazard Intrusiveness

The items measuring the intrusiveness of thoughts asked about the extent (*Not at* *all* = 1 to *Very great extent* = 5) to which respondents think about a volcanic eruption—think about it frequently; have vivid thoughts about it; have thoughts about it last for a long time; and many other thoughts remind them of it. Intrusiveness of thoughts was computed from the mean response over these four items. The intrusiveness of discussions items asked to what extent (*Not at all* = 1 to *Very great extent* = 5) the respondents talking about a volcanic eruption—bring it up frequently in discussions; other people bring it up frequently in discussions; discussions about it intense; and discussions about it last a long time. Intrusiveness of discussions was computed from the mean response over these four items.

3.2.7 Affective Response

The affective response items asked respondents to indicate the extent (*Not at all* = 1 to *Very great extent* = 5) that the possibility of a Mt. Rainier eruption made them feel—annoyed; depressed; nervous; safe; angry; secure; fearful; sad; worried; prepared; frustrated; and disappointed. Affective response was computed from the mean response over these twelve items.

3.2.8 Community Bondedness

Community bondedness was examined by asking respondents to report their degree (*Strongly disagree* = 1 to *Strongly agree* = 5) of agreement with six statements—I feel like I belong in this community; I believe my neighbors would help me in an emergency; Even if I had the opportunity I would not move out of this community; I feel loyal to the people in my community; I often have friends over to my house to see me; and I plan to remain a resident of this community for a number of years. Community bondedness was computed from the mean response over these six items.

3.2.9 Past Information Search

Expected future information search and past information search were measured by either a five or a three point rating scale. The expected future information search item asked respondents to judge the likelihood (*Extremely unlikely* = 1 to *Extremely likely* = 5) of seeking three information types—Mt. Rainier eruption risks; community's lahar warning system; and community's lahar evacuation routes. Expected future information search was computed from the mean response over these three items. The previous information search item asked respondents to report (*No* = 1; *Don't know* = 2; *Yes* = 3) whether they have—attended any meetings on lahar response in their community; discussed the need for lahar response with official agencies; and discussed the need for lahar response with friends, relatives, or neighbors. Previous information search was computed from the mean response over these three items.

3.2.10 Demographic Variables

Tenure was measured by the number of years the respondents had lived—in Washington State; in their current community; and in their current residence. Of the demographic variables, respondent's age was measured in years and gender was measured as a dichotomy (*Male* = 0, *Female* = 1). Ethnic identity was measured as

White (=1), *Native American* (=2), *Black* (=3), *Hispanic* (=4), *Asian/Pacific Islander* (=5), *Mixed* (=6), and *Other* (= 7). Homeownership was a dichotomy (*Rent* = 0; *Own* = 1). Education was measured by *Elementary school* (=1), *Junior high/middle school* (=2), *High school/vocational school* (=3), *College degree* (=4), and *Graduate degree* (=5). Finally, yearly household income was measured as less than *$25,000* (=1), *$25,001–$50,000* (=2), *$50,001–$75,000* (=3), *$75,001–$100,000* (=4), and *over $100,000* (=5).

3.3 Geographic Information System (GIS) Data Management

The GIS data were collected from following sources:

- The Washington State Department of Natural Resources, which provides detailed spatial data for risk zones of lahars, lava flows, and pyroclastic flows.
- The geospatial data of towns, cities, roads, and Mt. Rainier in Pierce County, which were obtained through the Pierce County Open GeoSpatial Data Portal.

Using ArcGIS 10.2.2 software, I geocoded household data from the mail survey, and then merged spatial data (i.e., risk zones, roads, towns, and the location of Mt. Rainier) into GIS layers. Before creating maps, I utilized the GIS tool "ArcToolbox" to define all the shapefiles in Geographic Coordinate System (GCS) North American Datum 1983 and changed the projection to NAD 1983 StatePlane Washington South FIPS 4602 Feet.

Hazard proximity is composed of lahar zone location and crater proximity. To estimate the lahar zone location, I utilized the GIS tool "Select by Location" to determine whether the households are located inside or outside the large lahar zones (*Outside* = 0; *Inside* = 1). Figure 3 shows that about 74% of respondents live within the large lahar zones. To determine crater proximity, I calculated the distances (in miles) from households' physical addresses, to the Mt. Rainier crater. The results demonstrate that respondents' distances to the crater of volcano that range from 14 to 40 miles (see Fig. 3).

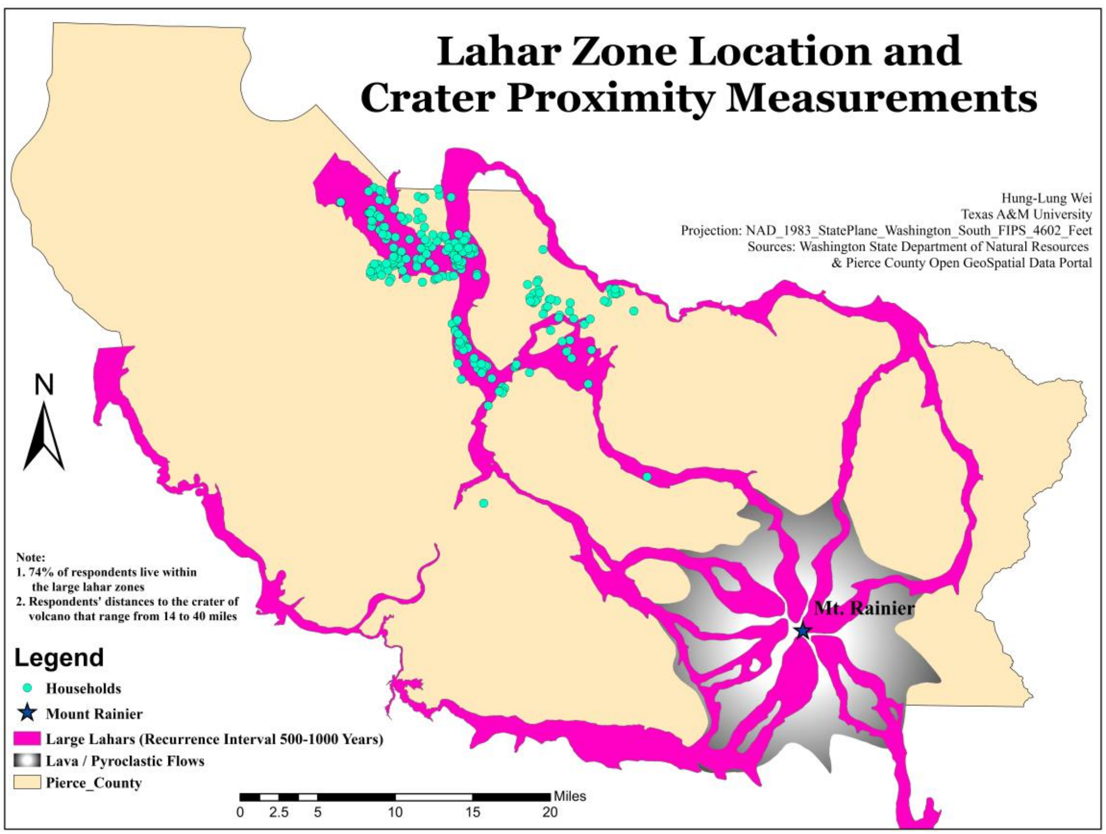

Figure 3 Measurements of Lahar Zone Location and Crater Proximity

3.4 Analytical Approaches

I used one-way analysis of variance (ANOVA) tests to address the research question (RQ). In addition, I conducted factor and scale analyses to develop and assess the construct validity and reliability of the indices for the six key psychological and hazard adjustment measures. For the factor analysis, I employed principal axis factoring as the extraction method, a scree test combined with the number of eigenvalues greater than one to determine the total number of factors, and varimax as the rotation method. With regard to reliability, I used Cronbach's alpha to estimate internal consistency reliability (Schutt, 2011). Finally, I utilized zero-order correlation, and six ordinary least squares (OLS) regression models to test the seven research hypotheses (RH 1–7) based on the conceptual model (see Fig. 1). The OLS regression model is one of the most widely used models in social science. In OLS, the dependent variable is assumed to be quantitative, continuous, and unbounded and this model assumes a linear relationship between the dependent and independent variables (Agresti & Finlay, 1997).

The six OLS regression models are specified as follows:

Model 1: The OLS regression is used to examine whether the independent variables (i.e., demographic variables; community bondedness; past information search; and hazard proximity) have significant effects on the interval dependent variable—risk perception.

Model 2: The OLS regression is applied to investigate whether the independent variables (i.e., demographic variables; community bondedness; past information search; and hazard proximity) have significant effects on the interval dependent variable—hazard intrusiveness.

Model 3: The OLS regression is employed to examine whether the independent variables (i.e., demographic variables; community bondedness; past information search; and hazard proximity) have significant effects on the interval dependent variable—affective response.

Model 4: The OLS regression is utilized to identify whether the independent variables (i.e., demographic variables; community bondedness; past information search; hazard proximity; risk perception; hazard intrusiveness; and affective response) have significant effects on the interval dependent variable—emergency preparedness.

Model 5: The OLS regression is applied to identify whether the independent variables (i.e., demographic variables; community bondedness; past information search; hazard proximity; risk perception; hazard intrusiveness; and affective response) have significant effects on the interval dependent variable—future information search.

Model 6: The OLS regression is employed to identify whether the independent variables (i.e., demographic variables; community bondedness; past and future information search; hazard proximity; risk perception; hazard intrusiveness; and affective response) have significant effects on the interval dependent variable—evacuation preparedness.

4. RESULTS

4.1 Demographic Characteristics of Respondents

Table 2 displays the respondents' mean tenure (Washington State: 47.1 years; Current community: 21.3 years; Current residence: 16.9 years), homeownership (Own: 88.8%; Rent: 9.8%), mean age (60 years), and gender (Male: 53.7%; Female: 45.3). Ethnicity is White (88.5%); Native American (2.6%); African American (0.5%); Hispanic (0.7%); Asian/Pacific Islander (1.9%); Mixed (1%) and Other (1.7%). Household income is less than $25,000 (9.5%); $25,001–50,000 (22.9%); $50,001–75,000 (18.6%); $75,000–10,0000 (11.7%); and over $100,000 (21.5%). Finally, respondents indicate their education as elementary school (0.2%), junior high/middle school (1.2%); high school/vocational school (42.7%); college degree (37.2%); and graduate degree (15%).

Table 2 Demographic Characteristics

Variable	Number	Percentage	Variable	Number	Percentage
Lived years and places			Ethnicity		
a. Washington State			Caucasian	371	88.5
Average: 47.1 years	415	99.0	Native American	11	2.6
Missing	4	1.0	African American	2	.5
b. Current Community			Hispanic	3	.7
Average: 21.3 years	412	98.3	Asian/Pacific Islander	8	1.9
Missing	7	1.7	Mixed	4	1.0
c. Current Residence			Other	7	1.7
Average: 16.9 years	412	98.3	Missing	13	3.1
Missing	7	1.7	Household Income		
Ownership			Less than $25,000	40	9.5
Rent	41	9.8	$25,001–50,000	96	22.9
Own	372	88.8	$50,001–75,000	78	18.6
Missing	6	1.4	$75,000–10,0000	49	11.7
Age			Over $100,000	90	21.5
Average: 60 years old	412	98.3	Missing	66	15.8
Missing	7	1.7	Education		
Gender			Elementary school	1	.2
Male	225	53.7	Junior high/middle school	5	1.2
Female	190	45.3	High school/vocational school	179	42.7
Missing	4	1.0	College degree (2 or 4 year)	156	37.2
			Graduate degree (Master, PhD)	63	15.0
			Missing	15	3.6

4.2 Mean Differences in Variables among Nine Communities

To address the RQ, one-way ANOVA tests were utilized to examine the mean differences among communities on different variables. Figure 4 shows that there are only minor differences among communities in *property damage by lahars* ($p < .01$), and Sumner has the highest mean rating ($M = 2.73$) in comparison with other eight communities.

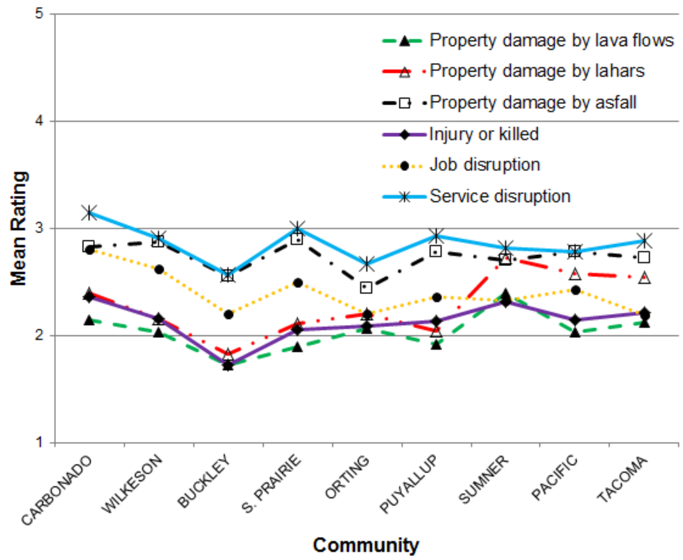

Figure 4 Mean Ratings of Risk Perception

In terms of hazard intrusiveness, there are also minor differences among communities in two attributes—*have vivid thoughts about it* and *frequent discussions by others* ($p < .01$); Carbonado ($M = 2.11$) is distinctive for *have vivid thoughts about it* and Orting ($M = 1.93$) is distinctive for *frequent discussions by others* (see Fig. 5).

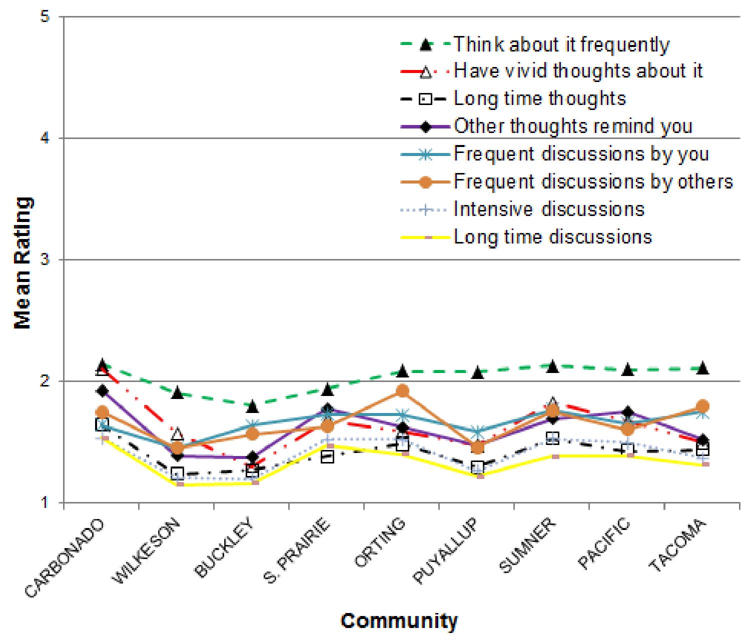

Figure 5 Mean Ratings of Hazard Intrusiveness

Figure 6 shows that there are only minor differences among communities in feelings of *prepared* ($p < .01$), and South Prairie has the highest mean rating ($M = 3.11$) of affective response compared to other eight communities.

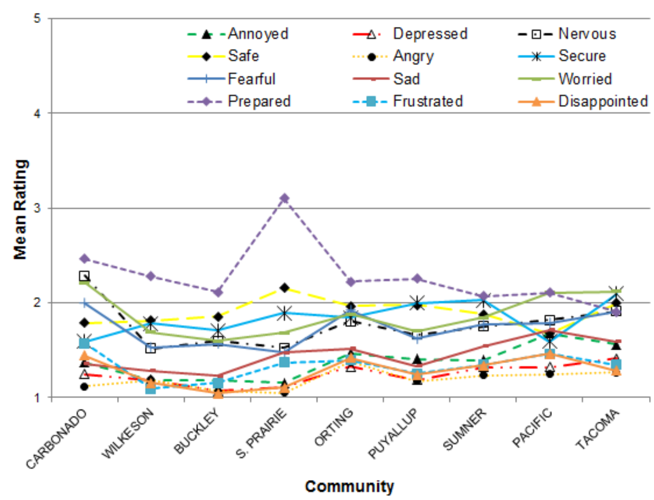

Figure 6 Mean Ratings of Affective Response

Figures 7 and 8 indicate that there are no significant differences among communities in two variables—expected future information search and adequacy of official lahar evacuation routes ($p > .05$).

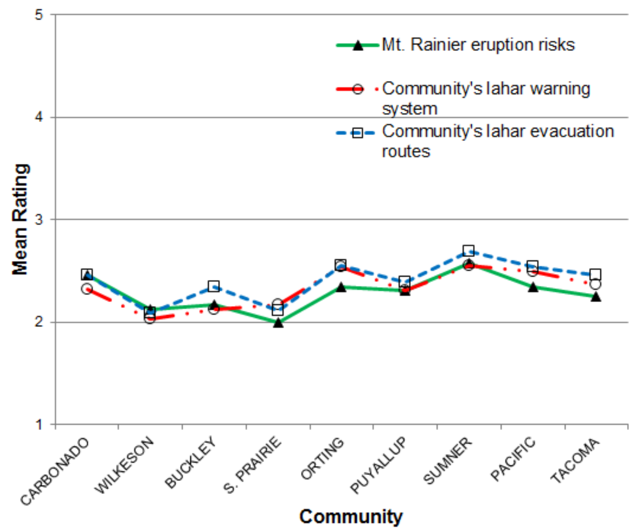

Figure 7 Mean Ratings of Expected Future Information Search

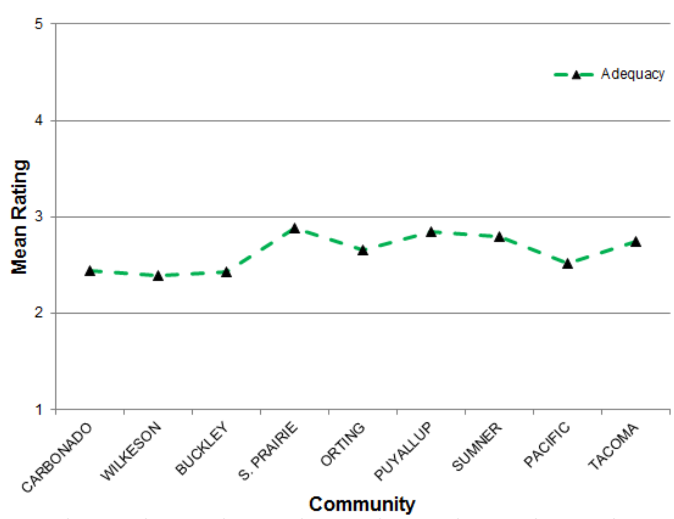

Figure 8 Mean Ratings of Adequacy of Official Lahar Evacuation Routes

As seen in Figure 9, there are significant differences among communities for three different responses—*receive an official lahar warning*, *prepare to evacuate*, and *evacuate to a safe location* ($p < .05$), and Sumner ($M = 4.03$) is distinctive for *receive an official lahar warning*, Orting ($M = 3.52$) is distinctive for *prepare to evacuate*, and Puyallup ($M = 3.66$) is distinctive for *evacuate to a safe location* have the highest mean ratings.

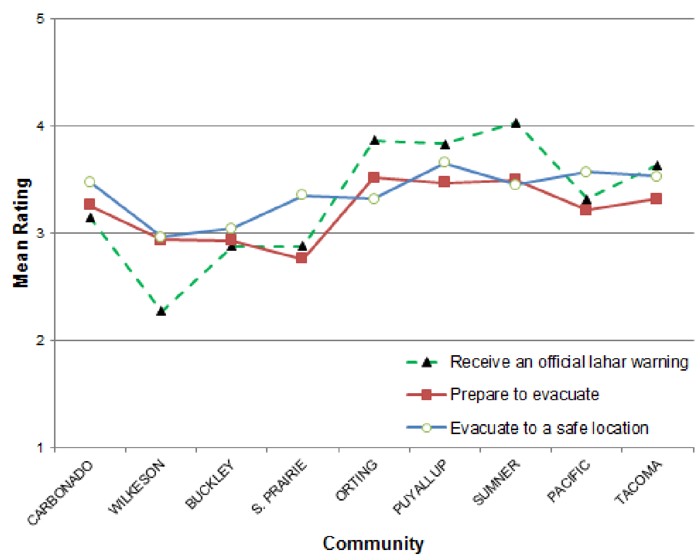

Figure 9 Mean Ratings of Evacuation Plan Effectiveness

With respect to school lahar evacuation plan compliance, there are no significant differences among nine communities regarding *trust in the school's evacuation plan*, *leaving the child at school*, and *getting the child from school* (see Fig. 10). In addition, there are no significant differences among the nine communities in the three attributes of adequate preparedness (see Fig. 11).

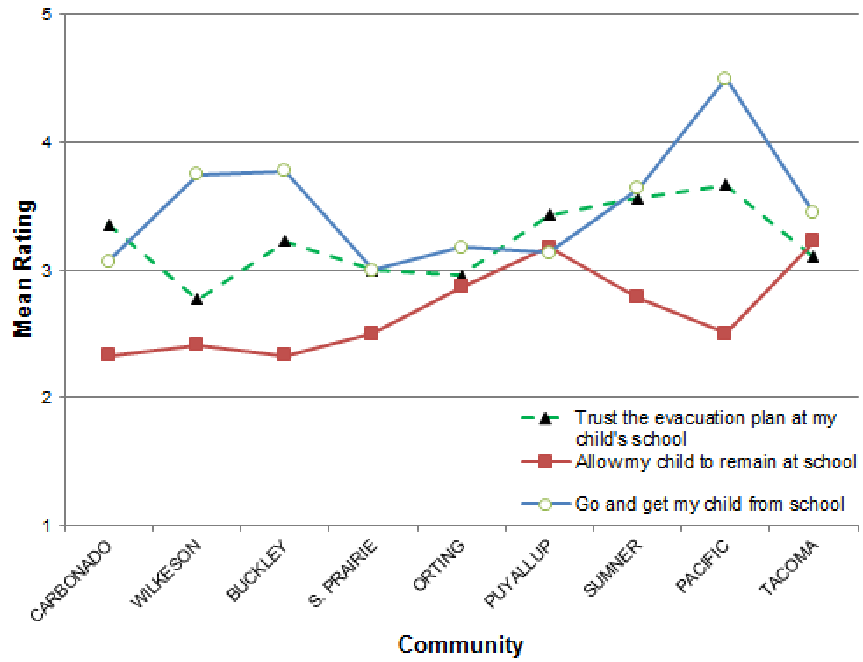

Figure 10 Mean Ratings of Schools' (K-12) Lahar Evacuation Plan Compliance

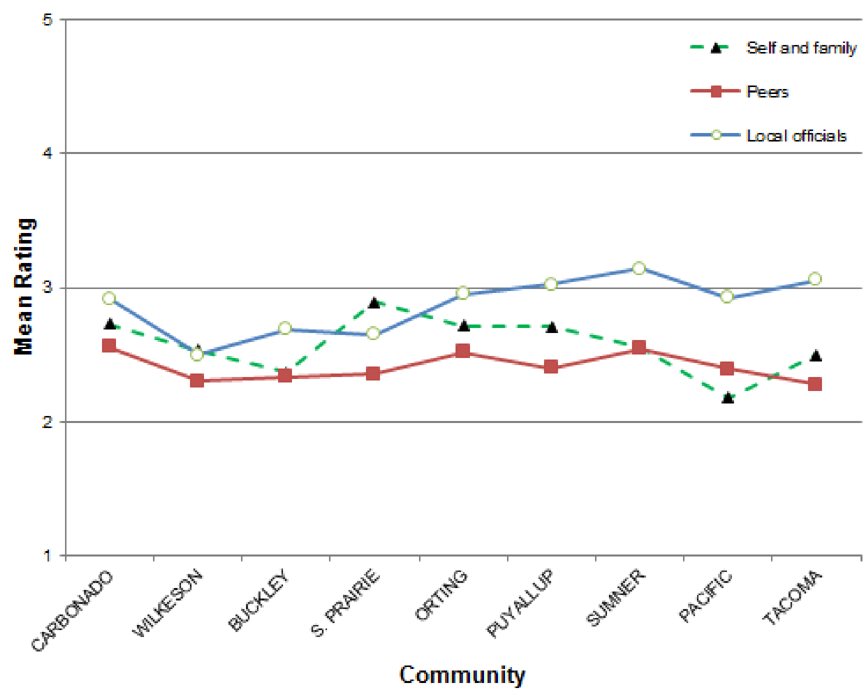

Figure 11 Mean Ratings of Adequate Preparedness

Finally, Figure 12 shows the means for the nine communities on the four attributes of community bondedness—*expected help from neighbors*, *would not move out*, *community loyalty*, and *stay in this community* ($p < .05$). South Prairie (M = 4.32; M = 4.42) has the highest mean ratings for *expected help from neighbors* and *stay in this community*, Wilkeson (M = 4.06) has the highest mean rating for *would not move out*, and Carbonado (M = 4.11) has the highest mean rating for *community loyalty*.

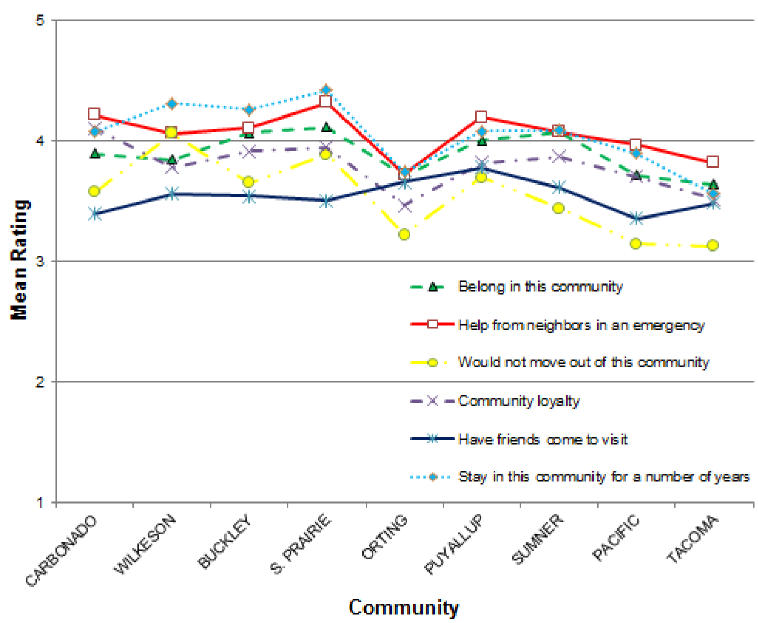

Figure 12 Mean Ratings of Community Bondedness

As seen in Table 3, some communities (e.g., South Prairie, Wilkeson, and Carbonado) have significantly higher mean ratings than the others while communities such as Orting and Tacoma have significantly lower mean ratings. The differences between the lowest and highest rated community bondedness ranged from 15.0% to

23.3% of the range of the 1-5 response scale and are statistically significant at $p < .05$.

Table 3 Profile Analysis Results for Community Bondedness

Attribute	Low	Mean	High	Mean	Difference	% of scale
Help from neighbors	ORTING	3.72	SOUTH PRAIRIE	4.32	0.60	15.00
Not move out	TACOMA	3.13	WILKESON	4.06	0.93	23.25
Community loyalty	ORTING	3.46	CARBONADO	4.11	0.65	16.25
Stay in this community	TACOMA	3.56	SOUTH PRAIRIE	4.42	0.86	21.50

4.3 Community Emergency Preparedness and Evacuation

As Figure 13 illustrates, 63.1% of respondents report they are aware of the lahar warning system and 66.7 % of them believe that there is a lahar evacuation plan in their community.

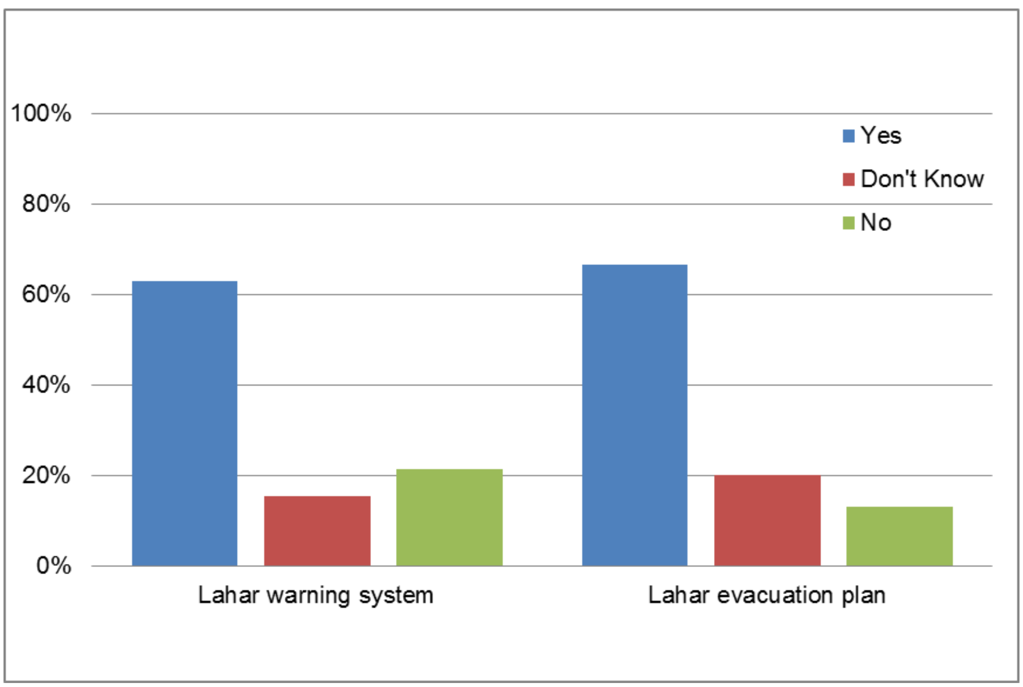

Figure 13 Percentage of Belief about Community Emergency Preparedness

Figure 14 depicts that most respondents will use cars (74.3%) or other motor vehicles (13.1%) to evacuate, but some will evacuate on foot (8.8%) or bicycles (3.8%). In terms of expected evacuation destination and routes, 59.6% of respondents have planned where to go if they evacuate from home while 58.4% of respondents have planned what evacuation routes to take (see Fig. 15). However, the percentages of those have practiced their community's official lahar evacuation routes are relatively low. As seen in Figure 16, very few households have followed official lahar evacuation routes during an official warning (5.8%) or training exercise (9.8%), but a significant percentage have been motivated by personal curiosity (26.8%).

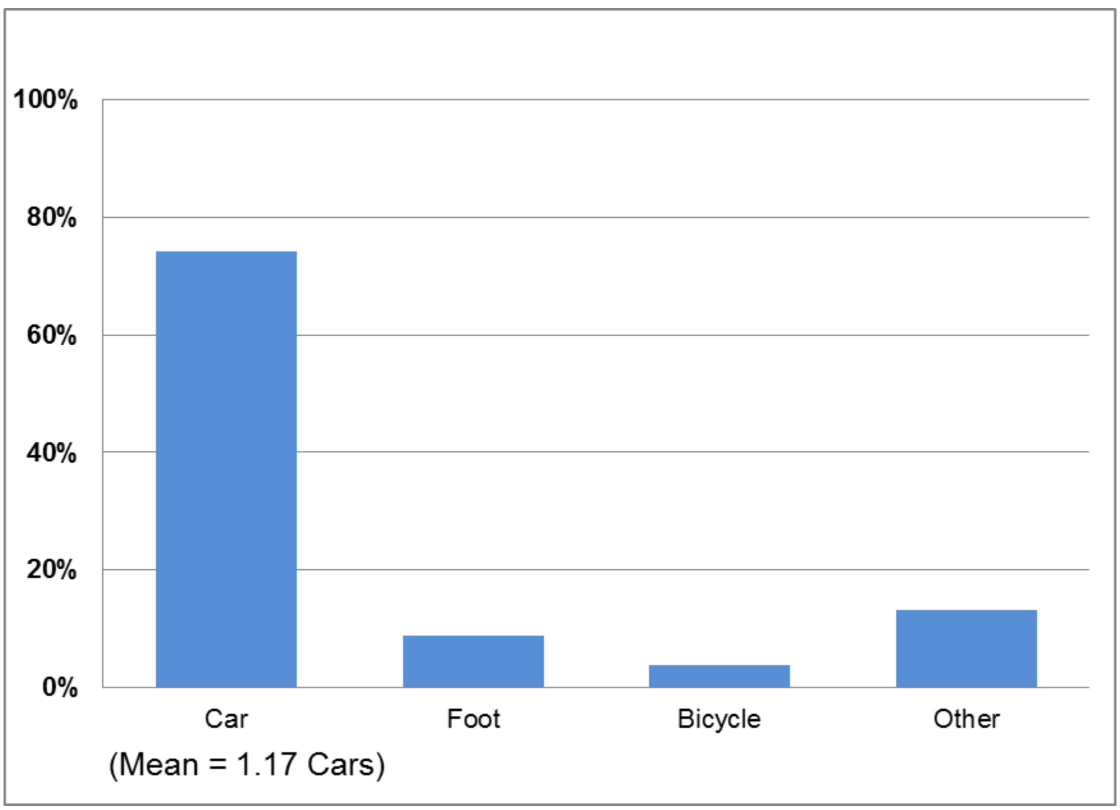

Figure 14 Percentage of Evacuation Transportation Mode

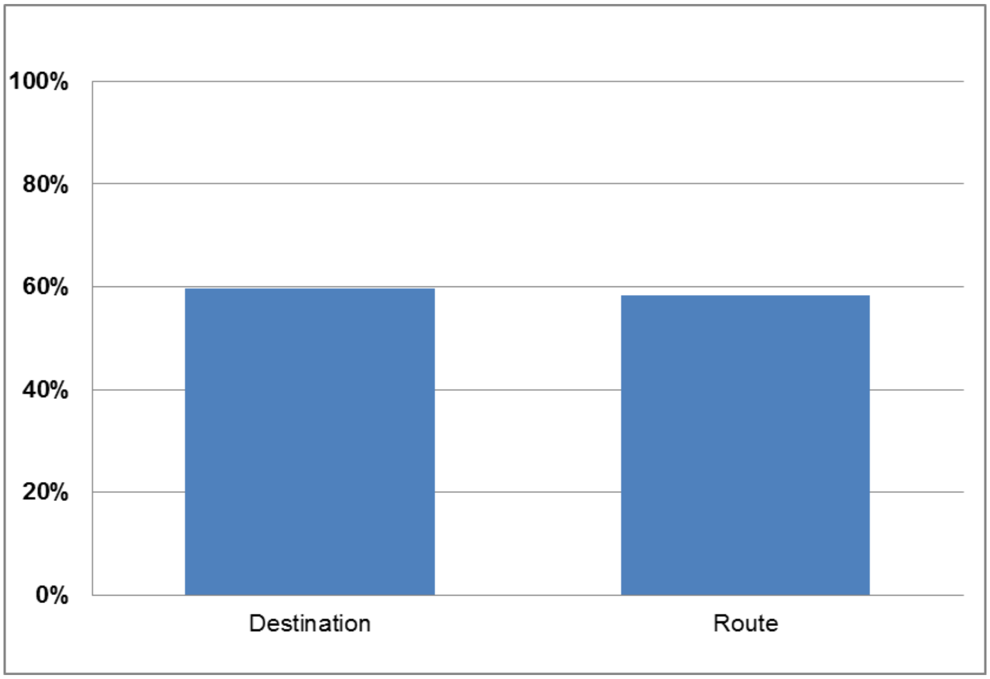

Figure 15 Percentage of Identified Own Evacuation Destination and Route

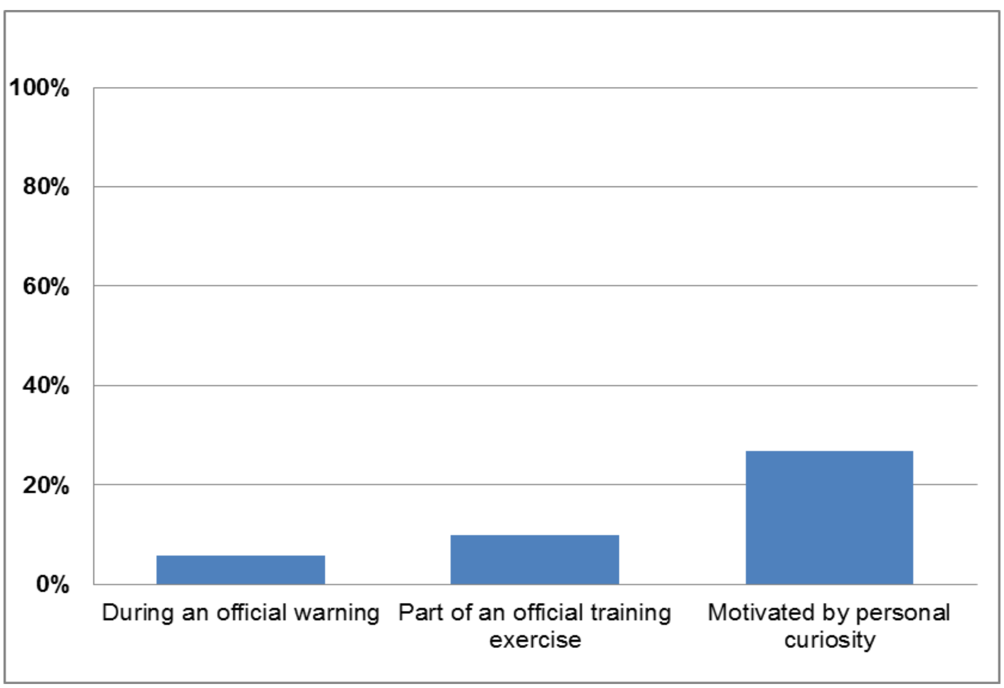

Figure 16 Percentage of Followed Community's Official Lahar Evacuation Routes

4.4 Factor and Scale Analyses

Factor analyses were utilized to assess the construct validity of the three psychological variables—risk perception, hazard intrusiveness, and affective response; and the three hazard adjustment measures—emergency preparedness, future information search, and evacuation preparedness. Also, using a factor analysis allows us to verify that the data are not characterized by halo error, the tendency for ratings of separate dimensions to be consistent with a global evaluation that yields a single factor (Cooper, 1981). The factor analysis of the psychological variables suggests that 5 factors have eigenvalues greater than 1.0, which is substantially more than the single factor that would be expected if the ratings are dominated by a halo effect.

In the factor analysis of the psychological variables, Table 4 reports the results of a 5-factor solution. The six items measuring risk perception (RiskPer—α = .93) and eight items measuring hazard intrusiveness (HazInt—α = .91) are included in the hypothesized two scales. The twelve items measuring affective response (Affect) form three scales—Angry (annoyed, depressed, angry, sad, frustrated, disappointed—α = .77), Fearful (nervous, fearful, worried—α = .91), and Safe (safe, secure, prepared —α = .77) but can be represented by a scale with α = .85.

A number of authors have argued that the minimum acceptable value for Cronbach's α is 0.70 (George & Mallery, 1995, 2003; Hill & Lewicki, 2006) but Schmitt (1996) has persuasively argued that the minimum acceptable value of depends on context—with lower levels being acceptable in exploratory research. Nonetheless, as seen in Table 4, all of the three psychological variables have high levels of reliability.

Table 4 Principal Axis Factors and Scale Reliabilities for Psychological Variables

Variables	Factors					Scale α
	1	2	3	4	5	
1.RskPerLava	.14	**.79**	.16	.02	-.03	
2.RskPerLhar	.14	**.81**	.20	.09	-.06	
3.RskPerAsh	.16	**.83**	.09	.10	.07	
4.RskPerCas	.14	**.82**	.16	.09	-.05	
5.RskPerJob	.24	**.72**	.07	.12	-.01	
6.RskPerSvc	.20	**.81**	.06	.12	.05	
RiskPer						.93
7.HIT_Frqnt	**.56**	.29	.20	.42	.04	
8.HIT_Vivid	**.63**	.32	.26	.19	-.05	
9.HIT_Long	**.63**	.25	.40	.22	-.01	
10.HIT_Remind	**.58**	.28	.31	.17	-.00	
11.HID_Frqnt	**.65**	.17	.10	.33	.05	
12.HID_Vivid	**.69**	.09	.08	.18	.08	
13.HID_Long	**.82**	.19	.30	.02	.05	
14.HID_Remind	**.80**	.14	.23	.03	.09	
HazInt						.91
15.Af_Annoyed	.21	.17	**.62**	.13	.18	
16.Af_Depressed	.27	.11	**.72**	.30	.02	
17.Af_Nervous	.34	.14	.40	**.68**	-.06	
18.Af_Safe	-.03	-.05	.00	-.04	**.93**	
19.Af_Angry	.21	.09	**.73**	.09	.11	
20.Af_Secure	-.03	-.01	.07	-.04	**.86**	
21.Af_Fearful	.32	.18	.43	**.68**	-.00	
22.Af_Sad	.16	.19	**.65**	.39	-.02	
23.Af_Worried	.36	.19	.36	**.64**	-.06	
24.Af_Prepared	.16	.01	.13	.02	**.46**	
25.Af_Frustrated	.22	.12	**.80**	.18	.06	
26.Af_Disappointed	.18	.14	**.86**	.06	.06	
Affect						.85

Note: Bold entries have factor loadings > .45 and are included in the scales listed following the group of items loading on the corresponding factor.

In the analysis of the hazard adjustment items, Table 5 shows the results of a seven-factor solution in which items with factor loadings greater than 0.45. The 17 items measuring emergency preparedness (EmergPrep) load on four different factors. Variables 1, 4, 5, and 6 (HousePrep_A, E, F, and G) did not have loadings > .45, but were assigned to the scales on which they had the highest loadings. The seven household items form a scale with α = .65, the five emergency kit items form a scale with α = .82, the two items measuring community preparedness form a scale with α = .85, and the three items measuring perceptions of preparedness adequacy form a scale with α = .77. Overall, the 17 emergency preparedness items could be represented by a scale with α = .77. Even if we delete any items from the emergency preparedness scale, the Cronbach's α value for the scale would not noticeably increase.

In addition, the three items measuring future information seeking (FutureInfo) form a scale with α = .92. Finally, five of the six items measuring evacuation preparedness (EvaPrep) form two scales (Route/Destination— α = .80 and Plan Success— α = .80). Expected evacuation mode (ExEvMode) did not load on any of the common factors so it is retained as a separate variable.

Two measures of hazard adjustment have reasonable levels of reliability (emergency preparedness: α = .77, and future information: α = .92). On the other hand, the third hazard adjustment measure—evacuation preparedness has a relatively lower level of reliability (α = .58). If expected evacuation mode is deleted, the value for evacuation preparedness would increase to .71—a more acceptable level of reliability.

Table 5 Principal Axis Factors and Scale Reliabilities for Hazard Adjustment Measures

Variables	**Factors**							**Scale α**
	1	2	3	4	5	6	7	
1.HousePrep_A	.11	-.03	.44	.01	.05	.07	.05	
2.HousePrep_B	.16	.08	**.48**	-.04	.04	-.01	-.07	
3.HousePrep_C	.15	.02	**.62**	.06	.07	-.00	-.01	
4.HousePrep_D	.21	.03	**.50**	-.02	.05	-.00	.12	
5.HousePrep_E	.02	.03	.40	-.01	-.10	-.00	.11	
6.HousePrep_F	-.02	-.03	.34	.06	-.05	.09	.00	
7.HousePrep_G	.14	-.00	.39	-.08	.09	.08	.06	
8.HousePrep_H	**.54**	.05	.13	-.01	.02	.07	.12	
9.HousePrep_I	**.61**	.03	.08	-.04	.05	.04	.03	
10.HousePrep_J	**.78**	-.02	.14	-.00	.08	.05	.01	
11.HousePrep_K	**.76**	.02	.21	.10	.08	.07	-.03	
12.HousePrep_L	**.66**	-.04	.20	.07	.04	.16	.02	
13.ComPrep_A	.02	.03	-.05	**.98**	.07	.03	.08	
14.ComPrep_B	.01	.04	-.02	**.71**	.10	.09	.16	
15.AdeqPrep_A	.29	.10	.42	.05	.26	**.48**	.22	
16.AdeqPrep_B	.17	.12	.08	.02	.10	**.89**	.03	
17.AdeqPrep_C	.13	.04	.10	.19	.26	**.63**	.13	
EmergPrep								.77
18.FutInfo_Risk	-.01	**.79**	-.01	.00	.01	.08	.02	
19.FutInfo_Warn	.03	**.96**	.05	.07	.03	.04	.05	
20.FutInfo_Evac	.04	**.93**	.03	.06	.03	.05	.05	
FutureInfo								.92
21.ExEvMode	-.02	-.07	-.08	-.07	.15	-.04	.04	
22.ExEvDest	.09	.08	.12	.13	.06	.03	**.76**	
23.ExEvRte	.05	.02	.14	.11	.11	.15	**.82**	
24.EvPlanWarn	.10	.14	.10	.44	**.51**	.17	-.02	
25.EvPlanPrep	.15	.08	.08	.16	**.79**	.18	.05	
26.EvPlanTrav	.12	.03	.09	.11	**.76**	.23	.08	
EvaPrep								.58

Note: Bold entries have factor loadings > .45 and are included in the scales listed following the group of items loading on the corresponding factor.

4.5 Correlation Analysis

As predicted by RH1 (Volcano risk perception will be significantly correlated with hazard intrusiveness and affective response), Table 6 shows that risk perception (RiskPer) is positively correlated with hazard intrusiveness (HazInt—r = .48) and affective response (Affect—r = .34).

Partially consistent with RH2 (The psychological variables—risk perception, hazard intrusiveness, and affective response—will be positively related to demographic variables of community tenure, female gender, and age, but negatively related to households' income, white ethnicity, and education), Table 6 shows that risk perception has a positive correlation with female gender (r = .15), but nonsignificant correlations with age (r = .07, *ns*) and community tenure (r = -.01, *ns*). As hypothesized, risk perception is negatively correlated with income (r = -.22), education (r = -.10), and white ethnicity (r = -.14). Similarly, affective response has a positive correlation with female gender (r = .12), but negative correlations with income (r = -.18) and white ethnicity (r = -.17). However, hazard intrusiveness has negative correlations with age (r = -.10) and white ethnicity (r = -.11), but nonsignificant correlations with community tenure (r = -.09, *ns*), female gender (r = .06, *ns*), households' income (r = -.09, *ns*), and education (r = -.02, *ns*).

Table 6 Means (*M*), *SD*, and Correlations among Variables

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.RiskPer	2.40	1.00															
2.HazInt	1.60	.61	**.48**														
3.Affect	1.63	.61	**.34**	**.61**													
4.HousePrep	.58	.25	**.12**	.06	.04												
5.ComPrep	2.47	.72	.09	.05	.08	-.04											
6.AdeqPrep	2.64	.77	.09	**.12**	**.17**	**.40**	**.21**										
7.EmergPrep	1.88	.42	**.11**	.09	**.11**	**.39**	**.71**	**.82**									
8.FutureInfo	1.32	.54	**.46**	**.48**	**.34**	.09	**.11**	**.20**	**.21**								
9.ExEvMode	1.56	.74	.05	-.10	-.02	-.03	-.02	.03	-.01	-.05							
10.ExEvDest	.60	.49	.08	**.13**	.09	**.17**	**.25**	**.23**	**.32**	**.12**	.02						
11.ExEvRte	.58	.49	**.11**	**.13**	**.11**	**.19**	**.23**	**.33**	**.37**	.08	.03	**.66**					
12.EvPlanEff	3.40	.97	.01	-.01	.03	**.17**	**.38**	**.49**	**.57**	**.16**	.09	**.19**	**.22**				
13.EvaPrep	1.54	1.33	.06	.04	.05	**.16**	**.37**	**.42**	**.51**	**.10**	**.35**	**.63**	**.66**	**.72**			
14.ComBond	3.81	.69	-.01	-.06	-.01	**.18**	-.09	**.22**	**.13**	.04	-.06	.03	.06	**.20**	**.15**		
15.PastInfo	1.32	.54	.06	**.25**	**.21**	**.23**	**.16**	**.32**	**.33**	**.19**	-.12	**.22**	**.29**	**.18**	**.22**	**.13**	
16. LZLocation	.74	.44	.04	.02	-.03	.00	**.10**	.04	.08	-.02	-.04	.04	.06	.05	.07	.02	.06
17.CProximity*	30.48	5.59	.07	**.10**	**.12**	-.02	**.40**	**.12**	**.27**	.09	.04	**.26**	**.18**	**.19**	**.22**	**-.18**	.06
18.Age	60.00	14.85	.07	**-.10**	.07	**.23**	-.04	.07	.04	-.05	.05	.04	.01	-.01	.02	.08	.04
19.Education	14.00	2.40	**-.10**	-.02	-.00	.09	**.13**	.05	**.13**	-.01	-.10	.05	.09	.05	.08	.09	**.18**
20.White	.91	.28	**-.14**	**-.11**	**-.17**	-.08	.01	**-.11**	-.06	-.07	.07	.00	.01	.02	.05	**.11**	-.04
21.Female	.46	.50	**.15**	.06	**.12**	**-.28**	**.13**	**-.11**	-.03	**.11**	.09	.01	-.08	.03	.01	-.06	**-.11**
22.Income**	54.33	10.25	**-.22**	-.10	**-.18**	.07	.02	-.05	.00	-.09	**-.14**	-.03	-.06	-.02	**-.11**	.00	.04
23.Tenure	28.47	13.37	-.01	-.09	.03	**.21**	**-.12**	.04	-.02	**-.10**	.05	.07	.06	.00	.05	**.15**	-.00
24.HomOwn	.90	.30	-.08	-.02	-.05	**.13**	-.08	-.03	-.05	-.06	**-.16**	.06	.03	-.06	-.05	.07	.04

Note:
1 CProximity* is measured in mile; Income** is measured in US $1,000
2. Yellow cells indicate correlations significant at $p \leq .05$
3. Green cells indicate significant results in supporting Hypotheses 1-7

Table 6 Means (*M*), *SD*, and Correlations among Variables

Variable	M	SD	16	17	18	19	20	21	22	23
1.RiskPer	2.40	1.00								
2.HazInt	1.60	.61								
3.Affect	1.63	.61								
4.HousePrep	.58	.25								
5.ComPrep	2.47	.72								
6.AdeqPrep	2.64	.77								
7.EmergPrep	1.88	.42								
8.FutureInfo	1.32	.54								
9.ExEvMode	1.56	.74								
10.ExEvDest	.60	.49								
11.ExEvRte	.58	.49								
12.EvPlanEff	3.40	.97								
13.EvaPrep	1.54	1.33								
14.ComBond	3.81	.69								
15.PastInfo	1.32	.54								
16. LZLocation	.74	.44								
17.CProximity*	30.48	5.59	-.05							
18.Age	60.00	14.85	.01	.04						
19.Education	14.00	2.40	.03	-.01	-.10					
20.White	.91	.28	-.04	-.02	.01	-.04				
21.Female	.46	.50	**.12**	**.13**	-.05	-.02	.02			
22.Income**	54.33	10.25	.02	**-.12**	**-.36**	**.28**	.10	**-.24**		
23.Tenure	28.47	13.37	.07	**-.11**	**.57**	-.09	.06	-.09	**-.22**	
24.HomOwn	.90	.30	.01	**-.15**	.05	-.01	.01	**-.15**	**.24**	**.21**

Note:

1 CProximity* is measured in mile; Income** is measured in US $1,000

2. Yellow cells indicate correlations significant at $p \leq .05$

3. Green cells indicate significant results in supporting Hypotheses 1-7

Consistent with RH3a (Community bondedness will be significantly correlated with community tenure), Table 6 indicates that community bondedness (ComBond) is significantly and positively associated with community tenure (r = .15). Partially consistent with RH3b (Community bondedness will be positively correlated with the three psychological variables, and all three components of hazard adjustment—emergency preparedness [i.e., household emergency preparedness, community emergency preparedness, and adequate preparedness], future information search, and evacuation preparedness [i.e., expected evacuation mode, destination and routes, and evacuation plan effectiveness]), community bondedness is significantly positively related to emergency preparedness (EmergPrep—r = .13) and evacuation preparedness (EvaPrep—r = .15), but not three psychological variables (RiskPer—r = -.01, *ns*; HazInt—r = -.06, *ns*; and Affect—r = -.01, *ns*) or future information search (r = .04, *ns*).

Partially consistent with RH4 (Past hazard information search will be significantly correlated with the three psychological variables, and all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness), Table 6 indicates that past hazard information search (PastInfo) is significantly and positively correlated with all three components of hazard adjustment—emergency preparedness (r = .33), future information search (r = .19), and evacuation preparedness (r = .22). Surprisingly, past information search has significant correlations with two psychological variables (HazInt—r = .25; and Affect—r = .21), but a nonsignificant relationship with risk perception (r = .06, *ns*).

Partially consistent with RH5 (Hazard proximity (i.e., lahar zone location and crater proximity) will be significantly correlated with the three psychological variables, and all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness), the results of Table 6 indicate that only crater proximity (CProximity) has significant positive correlations with hazard intrusiveness (r = .10), affective response (r = .12), emergency preparedness (r = .27), and evacuation preparedness (r = .22). However, the two hazard proximity variables are not significantly related to either risk perception (LZLocation—r = .04, *ns*; CProximity—r = .07, *ns*) or future information search (LZLocation—r = -.02, *ns*; CProximity—r = .09, *ns*).

Partially consistent with RH6 (Hazard adjustment adoption (i.e., emergency preparedness, future information search, and evacuation preparedness) will be positively correlated with risk perception, hazard intrusiveness, affective response, household income, tenure, and homeownership), Table 6 indicates that emergency preparedness is significantly and positively correlated with risk perception (r = .11) and affective response (r = .11). Future information search is significantly and positively related to risk perception (r = .46), hazard intrusiveness (r = .48), and affective response (r = .34), but significantly and negatively related to tenure (r = -.10). Interestingly, evacuation preparedness has a significant relationship with household income (r = .11), but nonsignificant relationships with risk perception (r = .06, *ns*), hazard intrusiveness (r = .04, *ns*), affective response (r = .05, *ns*), tenure (r = .05, *ns*), and homeownership (r = -.05, *ns*). Among the three components of hazard adjustment (i.e., emergency preparedness, future information search, and evacuation preparedness), only future information search has a significant correlation with tenure (r = -.10).

Partially consistent with RH7 (There will be relatively low levels of hazard intrusiveness [i.e. thought and discussion], but this variable will be more strongly correlated with all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness—than the other psychological variables [e.g., risk perception and affective response]), Table 6 indicates that hazard intrusiveness has a very low mean value (M = 1.6) based on a 5-point Likert scale. However, its correlation with emergency preparedness (r = .09, *ns*) is approximately the same at that of risk perception (r = .11) and affective response (r = .11). In addition, its correlation with future information search (r = .48) is approximately the same at that of risk perception (r = .46) but somewhat higher than affective response (r = .35). Finally, its correlation with evacuation preparedness (r = .04, *ns*) is approximately the same at that of risk perception (r = .06, *ns*) and affective response (r = .05, *ns*).

4.6 Ordinary Least Squares (OLS) Regression Model

The results of zero-order correlations reported in Table 6 could provide some support for the conceptual model (see Fig. 1). However, these correlations do not provide a complete test because they cannot determine which variables have higher significant effects on the three psychological variables (i.e., risk perception, hazard intrusiveness, and affective response) and three hazard adjustment variables (i.e., emergency preparedness, future information search, and evacuation preparedness) when other variables are controlled. Therefore, I apply six OLS regression models to examine the significant predictors for the psychological and hazard adjustment variables and identify whether these significant predictors are consistent with the results of the zero-order correlations.

Regarding the prediction of risk perception (Model 1), Table 7 indicates that only female gender has a significant positive regression coefficient (β = 0.12), whereas income (β = -0.13) and white ethnicity (β = -0.11) have significant negative regression coefficients. The signs of the regression coefficients for female gender, income, and white ethnicity are consistent with their zero-order correlations (see Table 6). Although education has a significant zero-order correlation, it does not have a significant regression coefficient. As expected, community bondedness, past information search, lahar and crater proximity, age, tenure, and homeownership are non-significant predictors of risk perception.

Table 7 Model 1: Prediction of Risk Perception

Variable	*b*	*SE(b)*	*B*
Constant	**2.51**	0.63	
ComBond	0.07	0.08	0.05
PastInfo	0.13	0.10	0.07
LZLocation	0.08	0.13	0.03
CProximity	0.00	0.01	0.02
Age	0.01	0.00	0.08
Education	-0.07	0.08	-0.05
White Ethnicity	**-0.41**	0.20	**-0.11**
Female Gender	**0.23**	0.12	**0.12**
Income	**-0.10**	0.05	**-0.13**
Tenure	-0.01	0.01	-0.07
HomOwn	-0.06	0.18	-0.02
F		(11, 318) = 2.50	
R^2		0.08	
Adj-R^2		0.05	
N		330	

Note: Bold entries have significant regression coefficients at $p \leq .05$

In predicting hazard intrusiveness (Model 2), Table 8 shows that only past information search has a significant positive regression coefficient (β = 0.28), whereas age (β = -0.18), income (β = -0.14), and white ethnicity (β = -0.11) have significant negative regression coefficients. The signs of the regression coefficients for past information search, age, income, and white ethnicity are consistent with their zero-order correlations. Interestingly, income has a significant regression coefficient even though it has a nonsignificant correlation in Table 6. Conversely, crater proximity has a significant correlation but a nonsignificant regression coefficient. Consistent with their zero-order correlations, community bondedness, lahar zone location, education, female gender, tenure, and homeownership have nonsignificant regression coefficients.

Table 8 Model 2: Prediction of Hazard Intrusiveness

Variable	*b*	*SE(b)*	*B*
Constant	**2.02**	0.37	
ComBond	-0.03	0.05	-0.03
PastInfo	**0.31**	0.06	**0.28**
LZLocation	0.01	0.07	0.01
CProximity	0.00	0.01	0.03
Age	**-0.01**	0.00	**-0.18**
Education	-0.01	0.04	-0.02
White Ethnicity	**-0.25**	0.12	**-0.11**
Female Gender	0.01	0.07	0.01
Income	**-0.06**	0.03	**-0.14**
Tenure	0.00	0.00	0.04
HomOwn	0.04	0.10	0.02
F		(11, 319) = 3.99	
R^2		0.12	
$Adj\text{-}R^2$		0.09	
N		331	

Note: Bold entries have significant regression coefficients at $p \leq .05$

As for the prediction of affective response (Model 3), Table 9 shows that past information search (β = 0.24) has a significant positive regression coefficient, whereas white ethnicity (β = -0.21) has a significant negative regression coefficient. The signs of the regression coefficients for past information search, and white ethnicity are consistent with their zero-order correlations. Crater proximity, female gender, and income are significant correlated with affective response but have unpredicted significant regression coefficients in Model 3. However, community bondedness, lahar zone location, education, tenure, and homeownership have nonsignificant regression coefficients that are consistent with their nonsignificant correlations.

Table 9 Model 3: Prediction of Affective Response

Variable	*b*	*SE(b)*	*B*
Constant	**1.56**	0.34	
ComBond	0.01	0.05	0.02
PastInfo	**0.25**	0.06	**0.24**
LZLocation	-0.02	0.07	-0.02
CProximity	0.00	0.01	0.05
Age	0.00	0.00	-0.00
Education	0.01	0.04	0.01
White Ethnicity	**-0.42**	0.11	**-0.21**
Female Gender	0.09	0.06	0.08
Income	-0.05	0.03	-0.11
Tenure	0.00	0.00	0.05
HomOwn	-0.04	0.10	-0.02
F		(11, 318) = 4.52	
R^2		0.14	
Adj-R^2		0.11	
N		330	

Note: Bold entries have significant regression coefficients at $p \leq .05$

In terms of predicting emergency preparedness (Model 4), Table 10 indicates that community bondedness (β = 0.18), past information search (β = 0.25), and crater proximity (β = 0.34) have significant positive regression coefficients, whereas female gender (β = -0.12) has a significant negative regression coefficient. The signs of the regression coefficients for community bondedness, past information search, and crater proximity are consistent with their zero-order correlations. Unexpectedly, female gender has a significant regression coefficient even though it has a nonsignificant correlation with emergency preparedness. Also, risk perception and affective response are significantly correlated with emergency preparedness but have nonsignificant regression coefficients.

Table 10 Model 4: Prediction of Emergency Preparedness

Variable	*B*	*SE(b)*	*Β*
Constant	0.79	0.24	
ComBond	**0.11**	0.03	**0.18**
PastInfo	**0.18**	0.04	**0.25**
LZLocation	0.09	0.04	0.09
CProximity	**0.02**	0.00	**0.34**
RiskPer	0.04	0.02	0.11
HazInt	0.01	0.04	0.02
Affect	-0.02	0.04	-0.03
Age	0.00	0.00	0.09
Education	0.04	0.03	0.08
White Ethnicity	-0.08	0.07	-0.05
Female Gender	**-0.09**	0.04	**-0.12**
Income	0.01	0.02	0.04
Tenure	-0.00	0.00	-0.02
HomOwn	-0.01	0.06	-0.01
F		(14, 314) = 8.71	
R^2		0.28	
Adj-R^2		0.25	
N		329	

Note: Bold entries have significant regression coefficients at $p \leq .05$

With respect to the prediction of future information search (Model 5), Table 11 shows that only two variables—risk perception (β = 0.24), and hazard intrusiveness (β = 0.37)—have significant positive regression coefficients. The signs for these two predictors are identical to their zero-order correlations. Past information, affective response, female gender, and community tenure have significant correlations with future information search but have nonsignificant regression coefficients. Additionally, community bondedness, lahar zone location, crater proximity, age, education, white ethnicity, income and homeownership have nonsignificant regression coefficients that are consistent with their nonsignificant correlations.

Table 11 Model 5: Prediction of Future Information Search

Variable	*B*	*SE(b)*	*B*
Constant	-0.22	0.60	
ComBond	0.11	0.08	0.07
PastInfo	0.11	0.10	0.06
LZLocation	-0.06	0.11	-0.02
CProximity	0.00	0.01	0.03
RiskPer	**0.26**	0.06	**0.24**
HazInt	**0.67**	0.11	**0.37**
Affect	0.13	0.11	0.07
Age	0.00	0.00	0.02
Education	0.00	0.07	0.00
White Ethnicity	0.14	0.19	0.04
Female Gender	0.09	0.11	0.04
Income	-0.00	0.04	-0.00
Tenure	-0.01	0.00	-0.08
HomOwn	-0.05	0.16	-0.02
F	(14, 313) = 12.19		
R^2	0.35		
Adj-R^2	0.32		
N	328		

Note: Bold entries have significant regression coefficients at $p \leq .05$

Regarding the prediction of evacuation preparedness (Model 6), Table 12 shows that four variables—community bondedness (β = 0.19), past information (β = 0.13), lahar zone location (β = 0.11), and crater proximity (β = 0.29)—have significant positive regression coefficients and income (β = -0.14) has a significant negative regression coefficient. The signs for these five significant predictors are consistent with their zero-order correlations. Interestingly, income has a significant regression coefficient even though it has a nonsignificant correlation in Table 6. Moreover, risk perception, hazard intrusiveness, affective response, age, white ethnicity, female gender, income, tenure, and homeownership have nonsignificant regression coefficients that are consistent with their nonsignificant correlations.

Table 12 Model 6: Prediction of Evacuation Preparedness

Variable	*B*	*SE(b)*	*B*
Constant	-0.01	0.28	
ComBond	**0.13**	0.04	**0.19**
PastInfo	**0.13**	0.04	**0.16**
LZLocation	**0.11**	0.05	**0.11**
CProximity	**0.02**	0.00	**0.29**
RiskPer	0.02	0.03	0.05
HazInt	-0.02	0.05	-0.03
Affect	-0.03	0.05	-0.04
Age	-0.00	0.00	-0.07
Education	0.04	0.03	0.08
White Ethnicity	-0.03	0.09	-0.02
Female Gender	-0.05	0.05	-0.06
Income	**-0.05**	0.02	**-0.14**
Tenure	0.00	0.00	0.12
HomOwn	0.01	0.07	0.01
F		(14, 314) = 5.37	
R^2		0.19	
Adj-R^2		0.16	
N		329	

Note: Bold entries have significant regression coefficients at $p \leq .05$

5. DISCUSSION AND CONCLUSIONS

5.1 Discussion

This research addresses a critical gap in the volcano literature by examining the effects of demographic variables, locational variables (i.e., crater proximity, lahar crater proximity and community bondedness), and past information search on three psychological variables (i.e., risk perception, hazard intrusiveness, and affective response). Subsequently, I investigated the effects of these psychological variables along with locational and demographic variables on three sets of household hazard adjustment variables (i.e., emergency preparedness, future information search, and evacuation preparedness). The factor analysis results indicated that risk perception, hazard intrusiveness, affective response, emergency preparedness, future information search, and evacuation preparedness are psychometrically distinct constructs.

I conducted one-way ANOVA tests to address the RQ—Are there mean differences in variables (i.e., risk perception, hazard intrusiveness, affective response, expected future information search, adequacy of official lahar evacuation routes, evacuation plan effectiveness, school evacuation plan compliance, adequate preparedness, and community bondedness) among nine communities? Regarding this research question, our findings indicate significant mean differences in five variables—risk perception, hazard intrusiveness, affective response, evacuation plan effectiveness, and community bondedness—among nine communities. However, no significant differences were found in the other four variables—future information search, adequacy of official lahar evacuation routes, school evacuation plan compliance, and adequate preparedness—among nine communities. Surprisingly, none of the significant differences among communities was related to distance from the volcano crater. Even more surprising is the fact that there were no significant differences among communities for lahars, although Figure 3 shows that communities closest to the volcano (especially Carbonado, Wilkeson, South Prairie, and Orting) are more susceptible to this hazard than communities farther away (especially Pacific and Tacoma). Most surprising of all is that risk perceptions of lava flows were almost identical to those of lahars, even though Figure 3 shows that all of the communities are too far from the volcano to be at risk from lava flows.

Next, I applied zero-order correlation analysis and six OLS regression models to test RH1-7. Overall, the results of this study fully supported only two research hypotheses. Specifically, the data are completely consistent with RH1 and RH3a; they are only partially consistent with RH2, RH3b, RH4, RH5, RH6, and RH7.

RH1 is fully supported by finding that risk perception (RiskPer) was positively correlated with hazard intrusiveness and affective response. These results confirm those of previous studies (e.g., Lindell et al., in press; Slovic et al., 2007; Slovic & Peters, 2006) that risk perception is related to affective reactions, particularly when risk perception is measured by perceived personal consequences (Lindell, 1994; Lindell et al., in press; Sjöberg, 2006). In addition, this finding is consistent with Ge et al.'s (2011) finding that risk perception, hazard intrusiveness, and worry were all highly intercorrelated.

RH2 is partially supported by finding that risk perception was positively correlated with female gender, but negatively correlated with income, education, and white ethnicity. However, the risk perception regression (Model 1) indicated that only female gender had a significant positive regression coefficient, whereas income and white ethnicity had significant negative regression coefficients. These findings are consistent with previous findings that risk perception was correlated with households' demographic characteristics—age (Barberi et al., 2008; Griffin et al., 1999; Hanson et al., 1979; Houts et al., 1984), female gender (Barberi et al., 2008; Fothergill, 1996; Griffin et al., 1999; Lindell & Hwang, 2008; Mileti & O'Brien, 1992; Peacock et al., 2005; Slovic, 2000; Tuner et al., 1986), lower education and income (Fothergill & Peek, 2004; Lindell & Hwang, 2008; Peacock et al., 2005), and ethnic minorities (Adeola, 2000; Fothergill et al., 1999; Hodge et al., 1979; Lindell & Hwang, 2008; Major, 1999; Mileti & O'Brien, 1992; Peacock et al., 2005; Tuner et al., 1986). However, the negative correlation of risk perception with community tenure is contrary to Peacock et al.'s (2005) finding. Hazard intrusiveness was negatively correlated with age and white ethnicity. Also, age and white ethnicity had significant regression coefficients in the prediction of hazard intrusiveness (Model 2). Affective response had significant correlations with female gender, income, and white ethnicity, but only white ethnicity had a significant regression coefficient in the prediction of affective response (Model 3). One plausible explanation for the negative regression coefficient for white ethnicity in predicting the three psychological variables— risk perception, hazard intrusiveness, and affective response—is that the minorities are more likely to perceive, think, and discuss the risks than the whites.

The finding of support for RH3a (community bondedness will be significantly correlated with community tenure) is important, because it confirms Bachrach and

Zautra's (1985) finding that community bondedness had a significant positive association with community tenure. Although this correlation is small (*r* = .15), it is important because, as noted below, community bondedness is significantly correlated with emergency preparedness (*r* = .13) and evacuation preparedness (*r* = .21). The positive effect of community bondedness on emergency preparedness and evacuation preparedness indicate that households that are live longer in their communities are more tightly integrated into those communities and are more likely to prepare and evacuate for volcanic hazards.

RH3b is partially supported by finding that community bondedness was positively correlated with household emergency preparedness, adequate preparedness, emergency preparedness, expected evacuation mode, evacuation plan effectiveness, evacuation preparedness—although it was not significantly related to future information search, expected evacuation destination, and expected evacuation route, risk perception, and community emergency preparedness. Moreover, community bondedness was a significant predictor in predicting emergency preparedness (Model 4) and evacuation preparedness (Model 6). These results are consistent with previous hazard studies (Barberi et al., 2008; Paton et al., 2001; Turner et al., 1986) reporting that community bondedness was relevant to hazard adjustment. However, community bondedness was not significantly correlated with risk perception, which is contrary to Barberi et al.'s (2008) finding.

The evidence for RH4 is mixed. Past hazard information search was significantly positively correlated with all three components of hazard adjustment. Specifically, it was significantly related to all four indicators of emergency preparedness, to future information search, and to all indicators of evacuation preparedness except expected evacuation mode. These findings are consistent with research on earthquakes and volcano activity that information seeking behavior was significantly related to hazard adjustment (Johnston et al., 1999; Mileti & Darlington, 1997; Mileti & Fitzpatrick, 1992; Perry & Lindell, 1990; Perry & Lindell, 2008). One likely explanation for the consistency is that information seeking is a hazard adjustment that requires time and effort, just as the other hazard adjustments do. Thus, risk area residents who have been willing to seek information in the past are more likely to seek information in the future—and also to engage in other hazard adjustments such as emergency preparedness and evacuation preparedness.

Surprisingly, however, past information search had a nonsignificant relationship with risk perception, which was also supported by the risk perception regression model (Model 1). One possible explanation for the inconsistency is that older residents and those with higher levels of education have been shown to be less confident in their own preparedness and less satisfied with the amount of information they had about the volcanic threat (Barberi et al., 2008).

RH5 is partially supported by discovering that crater proximity was positively correlated with emergency preparedness and evacuation preparedness. These findings were also supported by the emergency preparedness regression model (Model 4), in which crater proximity had a positive regression coefficient, and by the evacuation preparedness regression model (Model 6), in which lahar zone location and crater proximity both had positive regression coefficients. These findings are confirmed by other studies showing that hazard proximity was related to hazard adjustment (Farley et al., 1993) and evacuation (Gladwin & Peacock, 1997; Lindell et al., 2005; Wilmot & Mei, 2004). This consistency suggests that people who live close to hazards are more likely to adopt protective actions (e.g., emergency preparedness, future information search, and evacuation preparedness).

Surprisingly, lahar zone location and crater proximity were not significantly related to risk perception, which is consistent with Gavilanes-Ruiz et al.'s (2009) volcano research. However, this finding is contrary to a large number of hazard studies, reporting that perceived risk is associated with the proximity of natural hazard sources—volcano (Blong, 1984; Gregg et al., 2004a; Johnston et al., 1999), earthquake (Palm et al., 1990), and hurricane (Baker, 1991; Lindell et al., 2005; Lindell & Hwang, 2008; Peacock et al., 2005; Zhang et al., 2010). However, crater proximity was significantly correlated with hazard intrusiveness and affective response and had a much stronger correlation than lahar zone location with emergency preparedness. This suggests that proximity to the mountain is a much more salient cue to danger than location on a hazard map. Indeed, the difference between the results for crater proximity and lahar zone location might be due to few of the respondents ever having seen the lahar zone hazard map or, if they had, not being able to identify their location within it (Arlikatti et al., 2006; Zhang et al., 2004).

RH6 (Hazard adjustment adoption (i.e., emergency preparedness, future information search, and evacuation preparedness) will be positively correlated with risk perception, hazard intrusiveness, affective response, household income, tenure, and homeownership) was partially supported. As predicted, emergency preparedness was positively correlated with risk perception and affective response but, unexpectedly, not with hazard intrusiveness. The difference in the results for these three psychological variables is due to the fact that the correlation for hazard intrusiveness (r = .09) was just below the threshold for statistical significance whereas the correlations for risk perception (r = .11) and affective response (r = .11) were just above the threshold. Thus, none of the three psychological variables made a meaningful contribution to the prediction of emergency preparedness. It is possible that the psychological variables made trivial contributions because volcanic eruptions are generally less common than other natural hazards in the U.S. (e.g., earthquakes, tornadoes, wildfires, landslides, hurricanes, floods) so people have less experience with such events, resulting in lower levels of risk perception, hazard intrusiveness, and affective response.

Surprisingly, emergency preparedness had stronger correlations with community bondedness and, especially, crater proximity (but not lahar zone location) and past information search. The correlation of community bondedness with emergency preparedness, which might be due to peer communication about volcano hazards, tended to be higher in communities near the volcano. The correlation of past information search with emergency preparedness is consistent with other studies (e.g., Fitzpatrick & Mileti, 1992) in suggesting information search is an easy step toward more protective actions that have greater resource requirements. Finally, the nonsignificant correlation with lahar zone location suggests that many residents might never have seen the hazard map and, thus, do not realize that they are exposed to this hazard.

Also unexpectedly, the emergency preparedness regression model (Model 4) showed that female gender had a significant regression coefficient even though it had a nonsignificant correlation with emergency preparedness. Therefore, future research should continue to examine gender differences in hazard adjustment adoption (Lindell & Prater, 2000). In addition, risk perception and affective response lacked significant regression coefficients in Model 4 even though they had significant correlations with emergency preparedness. The most logical explanation for the inconsistency is that these two variables' small correlations (both of them $r = .11$) provided a negligible increment in prediction beyond that of the variables that did enter the equation—especially past information search and crater proximity.

As predicted, future information search was strongly related to the psychological variables—risk perception, hazard intrusiveness, and affective response. This finding is important because it is consistent with Griffin et al.'s (1999) model of risk information seeking and processing, suggesting that people's risk information seeking behavior in both routine and non-routine channels can be influenced by the three factors—individual characteristics, perceived hazard characteristics, and affective response to the risk. Surprisingly, affective response and community tenure have significant correlations with future information search but have nonsignificant regression coefficients.

The findings from the correlation analysis were confirmed by the future information search regression model (Model 5), which demonstrated that only risk perception and hazard intrusiveness were significant predictors. Although past information, affective response, female gender, and community tenure had significant correlations with future information search, they were not significant predictors in Model 5. The lack of significance for affective response can be explained by its high correlation with risk perception and hazard intrusiveness and its slightly lower correlation with future information search. The nonsignificance of the other variables is consistent with the notion that the effects of past information, female gender, and community tenure on future information search are mediated by the psychological variables.

Unexpectedly, evacuation preparedness only had significant correlations with community bondedness, past information search, crater proximity, and household income. With the exception of household income, this was the same set of variable that were correlated with emergency preparedness. The similarity in the predictors of these two variables is quite logical because evacuation preparedness was strongly correlated with emergency preparedness (r = .51).

In the evacuation preparedness regression model (Model 6), the variables with significant correlation coefficients (community bondedness, past information search, crater proximity, and income) also had significant regression coefficients. However, the regression coefficient for lahar zone location was statistically significant even though its correlation coefficient was not. The inclusion of lahar zone location in the regression equation is due to a slight increase in the magnitude of its regression coefficient (β = .11) over that of its correlation coefficient (r = .07).

To sum up, a significant relationship between hazard adjustment and risk perception has been found in some studies of earthquakes (Lindell & Perry, 2000), hurricanes and other storms (Peacock, 2003; Preston et al., 1983), and volcanic eruptions (Johnston et al., 1999; Perry & Lindell, 1990). However, this relationship has not been supported by other studies of the same and other environmental hazards (Lindell & Whitney, 2000; Paton et al., 2000; Perry & Lindell, 2008; Weinstein & Nicolich, 1993). Two components of hazard adjustment—evacuation preparedness and information search—were negatively correlated with income, which is consistent with Lindell and Hwang (2008). Moreover, the generally nonsignificant effects of the demographic variables are consistent with previous reports that demographic characteristics are weak and inconsistent predictors of immediate protective actions (Baker, 1991; Huang et al., in press) and hazard adjustment adoption (Lindell, 2013). Even though most of the demographic variables—age, white ethnicity, female gender, education, tenure, and homeownership—were not good predictors in predicting evacuation preparedness, we should continue to study them because it is important to assess the degree to which they have effects that are mediated by the psychological variables.

There was partial support for RH7 (There will be relatively low levels of hazard intrusiveness [i.e. thought and discussion], but this variable will be more strongly correlated with all three components of hazard adjustment—emergency preparedness, future information search, and evacuation preparedness—than the other psychological variables [e.g., risk perception and affective response]). Table 6 indicated that hazard intrusiveness had a very low mean value (M = 1.6) based on a 5 point Likert scale. This result is consistent with the findings of Barberi et al. (2008) and Ricci et al. (2013), which found relatively low levels of hazard salience (roughly equivalent to the present study's hazard intrusiveness variable), where the mean values were 2.26 and 2.47, respectively, on a 5 point scale.

Hazard intrusiveness was positively correlated with risk perception (r = .48), affective response (r = .61), and future information search (r = .48), but negatively correlated with two demographic variables—age (r = -.10) and white ethnicity (r = -.11). However, the hazard intrusiveness regression model (Model 2) showed that in addition to age and white ethnicity, income was also a significant predictor. Hazard intrusiveness was a significant predictor in predicting the past information search (Model 5). Surprisingly, hazard intrusiveness had nonsignificant relationships with two components of hazard adjustment—emergency preparedness and evacuation preparedness.

In summary, the above results are inconsistent with Lindell and Prater's (2000) finding that hazard intrusiveness was more strongly correlated with hazard adjustment than other variables—risk perception, and demographic variables. Instead, the present results are more like those of Ge et al. (2011), who found that risk perception, hazard intrusiveness, and worry were all highly, and approximately equally, correlated with expected mitigation incentive program participation.

5.2 Research Limitations and Future Research

It is important to acknowledge that this study has its limitations. First, although this research had a relatively high response rate (43%) compared with other mail surveys of environmental hazards, the sample may not represent all demographic categories. For example, respondents who participated in this survey were predominantly Caucasian (89%), older (60 years old), and homeowners (89%) with high school education (43%). Any overrepresentation of specific demographic categories will produce bias in other variables only to the degree that the demographic variables are correlated with those other variables. However, Table 6 shows that the correlations of demographic variables with other variables are small in this sample, as well as more generally (Huang et al., in press; Lindell, 2013; Lindell & Perry, 2000).

Second, this cross-sectional study cannot provide conclusive support for causal hypotheses because it is not possible to verify the temporal ordering of the psychological and self-report behavioral variables. For example, if respondents' reports of hazard intrusiveness and hazard adjustment are measured in the same questionnaire, we cannot rule out the possibility that recalling their levels of hazard adjustment influenced their estimates of hazard intrusiveness or vice versa. By contrast, a longitudinal design does provide evidence of temporal ordering (e.g., by measuring hazard intrusiveness at one point in time and then hazard adjustment at a later point in time) and, therefore, can reduce the possibility that the measurements of hazard adjustment and hazard intrusiveness have affected each other in spurious ways. To better make causal inferences about the hazard adjustment process, future research should adopt longitudinal designs.

Third, the study is nonexperimental because households were not randomly assigned to hazard proximity, so the omission of important unmeasured causal variables could bias the estimates of path coefficients (Lindell, 2008).

Finally, households' self-reports of risk perception and hazard adjustment adoption could be affected by systematic and random errors. For instance, exaggerated reporting of the hazard adjustment variables by all respondents would tend to add a constant error that would increase the variable means but leave the correlations unchanged. Differential bias across respondents would attenuate the correlations by adding random error and, thus, underestimate the true correlations. Although these reporting errors could, in principle, adversely affect this study's conclusions, other studies have found significant correlations between respondents' self-reports and observers' reports of environmental behaviors and, moreover, that reporting errors tend to be unsystematic (Lam & Cheng, 2002; Warriner et al., 1984). Nonetheless, future research should seek to examine the validity of self-reports in a broader range of domains.

5.3 Practical Implications

Although this dissertation has some limitations, it has some practical implications. First, the average risk perception of respondents was found to be low (M = 2.4, based on a 5 point scale). As Peacock et al. (2005) argued, increasing public participation and people's psychological reactions to their hazard exposure are significant factors that can influence the content of hazard mitigation programs and, thus, allowing people to prepare for and respond to environmental hazards. In addition, people's risk perceptions are likely to have an effect on community hazard adjustments such as emergency preparedness programs, building codes, and land use planning policies. Thus, local and state governmental officials need to devise strategies that can increase people's risk perceptions in order to prepare for and respond to disaster threats. This study suggests that risk communication strategies should address message content by describing the personal consequences of hazard impact and should provide repeated messages in order to increase the frequency of thought and discussion about the hazard. Risk communication programs that are designed in this way are more likely to produce affective reactions and appropriate hazard adjustments.

Second, the results revealed that most respondents had low levels of hazard intrusiveness and few engaged in volcano-specific emergency preparedness actions. This makes it essential for local emergency managers to increase residents' volcano hazard awareness and preparedness.

Third, lahar zone location has a weaker effect than crater proximity in predicting risk perception, hazard intrusiveness, affective response, emergency preparedness, and expectations of future information search. It is very likely that few risk area residents have seen a lahar zone risk map so they are unaware of the lahar risk, even if they are living in the lahar zones for the Mt. Rainier volcano. Therefore, local and state Departments of Emergency Management should collaborate with the USGS Volcano Hazards Program to disseminate lahar zone maps to risk area residents and conduct social vulnerability analysis to identify the vulnerable populations with regard to the volcanic threats (e.g., pyroclastic flows, lava flows, lahars, ash fall, gases, and acid rain).

Fourth, only about 60% of respondents reported that there is a lahar warning system and lahar evacuation plan in their communities, so it is important to increase the awareness of community preparedness. Awareness of community preparedness can be achieved in several ways. For example, educating the children in public schools (K-12) could be efficient and beneficial because it allows them to discuss the lahar warning system and lahar evacuation plan with their parents. The high level of community bondedness in this study suggests that community organizations can be trained to play an important role in instructing people about the lahar warning system and evacuation plan.

Fifth, very few households had followed official lahar evacuation routes during an official warning (5.8%) or training exercise (9.8%), but a significant percentage have been motivated by personal curiosity (26.8%). Thus, local emergency managers should arrange meetings for explaining the evacuation plan and provide incentives for promoting public participation.

Finally, due to the report of high percent of car usage (74.3%) and an increasing population growth in the Puyallup River valley, local emergency managers should collaborate with transportation engineers to conduct evacuation analyses to determine if the evacuation routes have adequate capacity for the likely evacuation demand. Such analyses should be coordinated with land use planners to determine if new evacuation route capacity will be needed to handle future population development in the lahar zone.

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APPENDIX A

1. How likely do you think it is that, within the next ten years, volcanic activity at Mt. Rainier will cause.......	Extremely unlikely	Unlikely	Even odds	Likely	Extremely likely
a. major damage your property by lava flows?	☐	☐	☐	☐	☐
b. major damage your property by lahars (volcanic mudflows)?	☐	☐	☐	☐	☐
c. major damage your property by ashfall?	☐	☐	☐	☐	☐
d. injure or kill you or members of your family?	☐	☐	☐	☐	☐
e. disrupt your job and prevent you from working?	☐	☐	☐	☐	☐
f. disrupt your access to electric, phone, and other basic services?	☐	☐	☐	☐	☐
2. When thinking about a volcanic eruption, to what extent do.......	**Not at all**	**Small extent**	**Moderate extent**	**Great extent**	**Very great extent**
a. you think about it frequently?	☐	☐	☐	☐	☐
b. you have vivid thoughts about it?	☐	☐	☐	☐	☐
c. your thoughts about it last for a long time?	☐	☐	☐	☐	☐
d. many other thoughts remind you of it?	☐	☐	☐	☐	☐
3. When talking about a volcanic eruption, to what extent.......	**Not at all**	**Small extent**	**Moderate extent**	**Great extent**	**Very great extent**
a. do you bring it up frequently in discussions?	☐	☐	☐	☐	☐
b. do other people bring it up frequently in discussions?	☐	☐	☐	☐	☐
c. are your discussions about it intense?	☐	☐	☐	☐	☐
d. do your discussions about it last a long time?	☐	☐	☐	☐	☐
4. To what extent does the possibility of a Mt. Rainier eruption make you feel....	**Not at all**	**Small extent**	**Moderate extent**	**Great extent**	**Very great extent**
a. annoyed	☐	☐	☐	☐	☐
b. depressed	☐	☐	☐	☐	☐
c. nervous	☐	☐	☐	☐	☐
d. safe	☐	☐	☐	☐	☐
e. angry	☐	☐	☐	☐	☐
f. secure	☐	☐	☐	☐	☐
g. fearful	☐	☐	☐	☐	☐
h. sad	☐	☐	☐	☐	☐
i. worried	☐	☐	☐	☐	☐
j. prepared	☐	☐	☐	☐	☐
k. frustrated	☐	☐	☐	☐	☐
l. disappointed	☐	☐	☐	☐	☐

5. Do you have any of the following items in the place where you live?	No	Yes
a. working transistor radio with spare batteries	☐	☐
b. at least 4 gallons of water in plastic containers	☐	☐
c. complete first-aid kit	☐	☐
d. 4 day supply of dehydrated or canned food for yourself and your family	☐	☐
e. fire extinguisher	☐	☐
f. flashlight and batteries	☐	☐
g. breathing protection for volcanic ash	☐	☐
6. Do you have any of the following in an emergency kit?	**No**	**Yes**
a. at least one week supply of prescription medicines	☐	☐
b. important documents (birth certificates, wills, inventory of household items)	☐	☐
c. cash, credit card, check book	☐	☐
d. at least one change of clothing per person	☐	☐
e. extra glasses or contact lenses	☐	☐

7. How likely is it that, in the near future, you will seek information about.....	Extremely unlikely	Unlikely	Even odds	Likely	Extremely likely
a. Mt. Rainier eruption risks	☐	☐	☐	☐	☐
b. your community's lahar warning system	☐	☐	☐	☐	☐
c. your community's lahar evacuation routes	☐	☐	☐	☐	☐

8. Does your community has a.....	No	Don't know	Yes
a. lahar warning system	☐	☐	☐
b. lahar evacuation plan	☐	☐	☐

9. If you receive a lahar warning, how do you intend to evacuate?

☐ Car ☐ Foot ☐ Bicycle ☐ Other ____________________

10. How many cars do you plan to take to evacuate? ______ Cars

11. Have you planned where to go if you evacuate from home?

☐ No ☐ Yes ____________________

12. Have you planned what route to take if you evacuate from home?

☐ No ☐ Yes (what roads?)

13. Have you ever followed your community's official lahar evacuation route(s).....	No	Yes
a. during an official warning?	☐	☐
b. as part of an official training exercise?	☐	☐
c. motivated by personal curiosity?	☐	☐

14. To what extent do you think the official evacuation routes provide adequate means of evacuation from a lahar?	Not at all	Small extent	Moderate extent	Great extent	Very great extent
	☐	☐	☐	☐	☐

15. How likely do you think it is that each of the following will happen after an eruption begins *but before a lahar*	Extremely unlikely	Unlikely	Even odds	Likely	Extremely likely
a. you will receive an official lahar warning	☐	☐	☐	☐	☐
b. you can prepare to evacuate	☐	☐	☐	☐	☐
c. you can evacuate to a safe location	☐	☐	☐	☐	☐

16. If you have a child in school (K-12), does your child's school have a lahar evacuation plan?

☐ No ☐ Don't know ☐ Yes ☐ Not applicable

17. To what extent to which you agree or disagree with each of the following statements?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. I trust the evacuation plan at my child's school to protect them	☐	☐	☐	☐	☐
b. I will allow my child to remain at school when a lahar warning	☐	☐	☐	☐	☐
c. I will get my child from school if a lahar warning is issued	☐	☐	☐	☐	☐

18.To what extent do you think each of the following is prepared for a major Mt. Rainier eruption?	Not at all	Small extent	Moderate extent	Great extent	Very great extent
a. You and your family?	☐	☐	☐	☐	☐
b. Other members of your community?	☐	☐	☐	☐	☐
c. Local officials of your community?	☐	☐	☐	☐	☐

19. Have you.......	No	Don't know	Yes
a. attended any meetings on lahar response in your community?	☐	☐	☐
b. discussed the need for lahar response with official agencies?	☐	☐	☐
c. discussed the need for lahar response with friends, relatives, or neighbors?	☐	☐	☐

20. To what extent to which you agree or disagree with each of the following statements?	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. I feel like I belong in this community	☐	☐	☐	☐	☐
b. I believe my neighbors would help me in an emergency	☐	☐	☐	☐	☐
c. Even if I had the opportunity I would not move out of this community	☐	☐	☐	☐	☐
d. I feel loyal to the people in my community	☐	☐	☐	☐	☐
e. I often have friends over to my house to see me	☐	☐	☐	☐	☐
f. I plan to remain a resident of this community for a number of years	☐	☐	☐	☐	☐

21. How long have you lived in the following places:

a. Washington State _________ years

b. The community you live in now ________ years

c. Your current residence __________ years

22. Do you rent or own the home where you now live? ☐ Rent ☐ Own

23. What is your age? ________ years old

24. What is your gender? ☐ Male ☐ Female

25. Which of the following best reflects your ethnicity?

☐ Caucasian ☐ Native American ☐ African American ☐ Hispanic
☐ Asian/Pacific Islander ☐ Mixed ☐ Other

26. Which of the following categories best describes your yearly household income before taxes?

☐ Less than $25,000 ☐ $25,001–50,000 ☐ $50,001–75,000
☐ $75,000–10,000 ☐ Over $100,000

27. Which best reflects the highest level of education that you completed?

☐ Elementary school ☐ Junior high or middle school ☐ High school or vocational school
☐ College degree (2 or 4 year) ☐ Graduate degree (Master, Ph.D., etc)

Do you have any other comments about household emergency preparedness for eruption of Mt. Rainier?

Thank You Very Much For Participating In This Study.