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Immediate Behavioral Response to the June 17, 2013 Flash Floods in Uttarakhand, North India

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Flash Floods in Uttarakhand, North India

The 2013 Uttarakhand flash flood was such a surprise for those at risk that the predominant source of information for their risk was environmental cues and, secondarily, peer warnings rather than official warnings. Of those who received warnings, few received information other than the identity of the flood threat. A survey of 316 flood survivors found that most people's first response was to immediately evacuate but some stayed to receive additional information, confirm their warnings, or engage in evacuation preparations. Unfortunately, engaging in these milling behaviors necessarily delayed their final evacuations. Mediation analysis revealed that psychological reactions mediated the relationship between information sources and behavioral responses. Further regression analyses revealed that immediate evacuation and evacuation delay were both predicted best by information search and positive affect, but correlation analyses indicated that a number of other models were also plausible. Final evacuation was best predicted by immediate evacuation and, to a significantly lesser extent, household together. For this dependent variable also, correlation analyses indicated that a number of other variables were almost as predictive as household together. The data from this event revealed some similarities but also some differences from other studies of rapid onset disasters, indicating that further research is needed to determine the relative importance of situational and cultural characteristics in producing the observed differences in household response to flash floods.

Overall, results suggest that the Protective Action Decision Model (PADM) should be considered more than a tentative framework for examining household responses to flash floods in developing countries like India. It supports the conclusion that a household's first warning source is a function of two distinct detection and dissemination systems within a community—an official system and an informal system. However, it fails to capture what pre-impact emergency preparedness for rapid onset events in a developing country context. Further research is needed to determine the relative importance of situational and cultural characteristics in producing these observed differences

Key words: Flash flood, warning, evacuation, psychological reactions, India

1.0 Introduction

Flood hazard is a serious threat to at least 20 million people worldwide, claiming approximately 20,000 lives every year (Kellens, Terpstra & De Maeyer 2013). Flash floods are distinct from most other types of flooding because they are rapid onset events, occurring within 2-6 hours of heavy rain, dam break, levee failure, rapid snowmelt, or ice jam (Federal Emergency Management Agency 1993). Flash floods are considered to be one of the most dangerous weather-related natural disasters in the world as they are involuntary risks for individuals who are unaware of event onset, have not chosen to associate with the event, and have no control over how the event will affect them (Knocke & Kolivras, 2007). People do monitor floods but rarely achieve a level of hazard knowledge that provides them with guidance about how to respond. Indeed, their mental models of flash floods are often deficient (Lazrus et al., 2015; Morss et al., 2015; Wagner, 2007). Hence, it becomes especially important to understand issues related to households' flash flood response. Unfortunately, the research literature on people's immediate responses to flash floods in developed countries is modest and the problem is even worse for developing countries. In these countries, official flash flood warning systems are rare, so people's traditional knowledge, prior experience, and integration into informal peer warning networks are likely to determine their immediate behavioral responses to a flash flood and, ultimately, whether they survive the event (Parker & Handmer, 1998). Thus, the objective of the present study is to better understand people's immediate response to the June 16–17, 2013 flash floods in the mountainous state of Uttarakhand in North India. This event claimed 169 documented lives lost, 4,021 reported missing and presumed dead, and more than nine million people affected (National Institute of Disaster Management 2015; Arlikatti et al., 2018).

The remainder of this article is divided into five sections. The rest of this section describes the study's theoretical foundation—the Protective Action Decision Model (Lindell, 2018; Lindell & Perry, 2004, 2012)—and reviews research on response to rapid onset disasters. It concludes with eight research objectives that examine the correlations of people's situational contexts, information sources, and psychological reactions with behavioral responses, as well as the best predictors of those behavioral responses. Section 2 provides a description of the Uttarakhand flash flood, the questionnaire items used in conducting a survey of flood survivors, and the sampling procedure that yielded 316 respondents. Section 3 presents the survey results and Section 4 discusses their theoretical and practical implications, as well as the study's limitations. Finally, Section 5 presents the study's conclusions.

1.1 Theoretical Foundation: Protective Action Decision Model

Disaster researchers have identified many ways in which people respond to rapid onset threats from earthquakes, flash floods, tornadoes, tsunamis, and volcanic eruptions (Lindell, 2012, 2013; Sorensen, 2000; Sorensen & Sorensen, 2007). In particular, the *Protective Action Decision Model* (PADM) summarizes the ways in which information sources; information channel access and preference; warning message content; perceptions of the threat, protective actions, and stakeholders; information search strategies, protective action decision making processes; and facilitating and inhibiting conditions affect behavioral responses such as information seeking, protective action, and emotion-focused coping (Lindell, 2018; Lindell & Perry, 2004, 2012). People's major information sources are environmental cues (sights, sounds, or smells that indicate disaster onset), social cues (observations of businesses closing and people evacuating), and social warnings from authorities, news media, and peers (Drabek, 1986). The social sources are differentiated in terms of their expertise, trustworthiness, and protection responsibility (Arlikatti, Lindell & Prater, 2007). Broadcast media (radio and TV) are extremely common warning sources in slow onset disasters such as hurricanes but peers are common first sources in very rapid onset hazards such as floods (Perry et al., 1981), volcanic eruptions (Perry & Greene, 1983), tornadoes (Lindell et al., 2013), and tsunamis (Lindell et al., 2015a).

Warning messages are most likely to produce appropriate protective actions if they describe the information source, threat, its location and arrival time, affected (and safe) areas, especially vulnerable populations, protective action recommendations, and sources to contact for additional information and assistance (Bean et al., 2015; Drabek, 1999; Lindell & Perry, 2004, Chapter 5). Other message characteristics include perceived source credibility, message consistency, message accuracy, message clarity, perceived confidence and certainty, guidance clarity, and message frequency (Mileti & Peek 2000; Peek & Mileti 2002) and comprehension agreement, dose-response consistency, hazard-response consistency, uniformity, audience evaluation, and types of communication failures (Weinstein & Sandman 1993). In addition, warning messages can vary in their format—verbal, numeric, or graphic (Wu et al., 2015).

Environmental and social cues and warning messages produce situational risk perceptions that can be characterized in term of expectations about casualties, damage, and disruption to the community in general and to one's family in particular (Huang et al., 2012, 2017). They also produce positive and negative affective responses (Lindell et al., 2016; Wei & Lindell, 2017). Depending on their perceptions of the information sources, the hazard, and alternative response actions, people either continue normal activities, actively seek (or passively await) additional information, or prepare for and take action to protect persons and property. However, people's search for additional information, attempts at family unification, and preparation for evacuation necessarily delay the initiation of protective actions such as evacuation (Arlikatti et al., 2015). People's choices of response actions can be frustrated by situational inhibitors (e.g., the lack of a reliable vehicle in which to evacuate) or enhanced by situational facilitators (e.g., the availability of neighbors who have room in their cars) that arise from their physical, social, and household contexts. People who evacuate are most likely to spend their time away from home with peers, somewhat less likely to stay in hotels or motels, and least likely to stay in public shelters (Lindell et al., 2011; Mileti et al., 1992; Wu et al., 2012; Wu et al., 2013).

Although there has been substantial support for this model, its generalizability to other cultures might be limited by the fact that most of the supporting studies have been conducted in the United States. Accordingly, this model should be considered a tentative framework for examining household responses to flash floods in India.

1.2 Response to Floods and other Rapid Onset Incidents

The Kellens et al. (2013) review of 57 empirically-based peer-reviewed articles on flood risk perception and communication noted that only a small amount of research has studied households' immediate behavioral response to imminent flooding. In some cases, risk area residents received no warning of an approaching flood. For example, Paul (1999) reported that only 25% of those surveyed after the 1998 Augusta/Arkansas City, Kansas flood received a warning in time to protect property—if they received one at all. Parker et al. (2007a) reported that only 27-69% of previously flooded households in seven different British surveys reported that they had received a warning.

Table I summarizes data from 17 different flood sites regarding the source of first notification of an event, source of first warning to evacuate, and first source contacted for threat confirmation (see the Appendix for the raw data from the flood sites as well as 8 other rapid onset hazard sites). These sites were selected because the authors already knew about them, they were identified by a Google Scholar search using "flood evacuation" as the search term, or they cited or were cited by the articles that had already been identified.

Overall, peers are the most common first source (38%) followed by environmental cues (33%), authorities (21%), and news media (17%). However, there is a slightly different pattern for threat confirmation with news media being the most common first source (35%) followed by peers (27%), authorities (20%), and environmental cues (0%). These sources vary significantly in the types of information reported, partly because of differences in study objectives but also because of differences in situational contexts. For example, Drabek's (1969; Drabek & Boggs, 1968) study of the 1965 Colorado floods reported about five hours of forewarning, whereas Perry et al. (1981) reported a range from no forewarning in Sumner, Washington to 3 hours in Valley, Nebraska. By contrast, Parker et al. (2007b) reported that 59% of their respondents had 8 hours or more of forewarning.

[Table I about here]

There is also significant variation within and between studies in people's behavioral response to their first warning. Perry et al. (1981) reported a substantial range in preparing to evacuate (16-51%), other protective action (5-30%), gathering or warning family members (7-22%), and continuing normal activities (17-38%). De Marchi et al. (2007) reported a similarly wide range of behavioral responses—immediate evacuation (26%), continuing normal activities (17%), relaying the warning to relatives (10%), seeking additional information/securing property/providing or receiving help with others (30%), and going to the river to verify the flood severity (18%)—a seemingly illogical action also reported in other studies (Lindell et al., 2015; Ruin et al., 2009). Similarly, Steinführer and Kuhlicke (2007) reported a pattern of immediate evacuation (28%), continuing normal activities (13%), and securing property (39%), but 10% reported receiving no information. Finally, Pescaroli and Magni (2015) reported that, among those warned by a siren alert, 29% warned others, 23% sought further information, 21% protected property, 18% continued normal activities, and only 2% prepared to evacuate. The low rate of evacuation in this study is likely due to sirens serving as an alert that something significant is happening without providing specificity about the identity of the threat, who is likely to be affected, what protective action is recommended, and how soon it should be implemented (see Perry et al., 1981 for further discussion of this point).

A recent study of the 2009 Samoa tsunami is also relevant to flash flood response because it involves a rapid onset hydrological threat. In this context, a rapid onset event is one in which life threatening conditions occur in less time than it takes to warn the entire risk area population with the technology that is available in that community. Lindell et al. (2015) found that an environmental cue—earthquake shaking combined with knowledge that this can cause a tsunami—was the most common (46%) source of first awareness of the threat and that broadcast media (15%) were slightly more common first social sources of warnings than were authorities (14%) or peers (11%). Few of the recommended elements of a warning message—nature of the threat (46%), affected areas (26%), safe areas (49%), protective action recommendations (35%), sources of assistance (10%) and further information (6%)—were communicated to those at risk and none of these message elements was significantly correlated with evacuation. More people received warning confirmation from peers (24%) than from the news media (16%) or authorities (12%). Nonetheless, two-thirds of coastal residents and half of inland residents began evacuations within 15 minutes after the earthquake. Those with greater risk perceptions were not more likely to evacuate but did evacuate more rapidly.

Similarly, the Wei et al. (2017) study of response to the threat of tsunamis after the 2011 earthquakes in Christchurch New Zealand and Hitachi Japan found that peers were more common confirmation sources (more than 73% in Christchurch and 50% in Hitachi) than news media (more than 48% in Christchurch and 37% in Hitachi). However, a study of response to the 2010 Boston water contamination incident reported that peers (42%) and news media (41%) were both more common sources of first warnings than authorities

(13%) but that news media (87%) were much more common than peers (25%) as confirmation sources (Lindell et al., 2017).

Two studies have tested multivariate models of flood warning response. Mileti and Beck's (1975) study of the 1972 Rapid City flood reported that 36% of their respondents received their first warning face-to-face and this increased to 47% for those who received a third warning; 29% of their respondents received a specific first warning and this increased to 49% for those who received a third warning. Their regression analyses showed that perceived warning certainty, warning belief, and proportion of households evacuating increased with the number of warnings; warnings received from news media increased warning confirmation; perceived warning certainty and warning confirmation predicted warning belief; specific own-area warnings, person-specific warnings, and warning belief predicted evacuation but intact (vs. separated) households did not—perhaps because of the urgency of a flash flood. Similarly, the Perry et al. (1981) Four Community study tested a path model that found warning response was significantly influenced by belief that a flood would strike and that it would threaten them personally, possession of a family emergency response plan, past flood experience, and community involvement (defined as frequency of contacts with peers).

1.3 Research Objectives

A major limitation of the research on floods and other rapid onset disasters described in the previous section is that most have been conducted in developed countries in Europe and North America, especially the US, but a disproportionate percentage of the flood deaths are in Asia (Lindell, 2013), so more research is needed on flood warning response in this part of the world. Moreover developed countries have robust programs for hazard detection and forecasting, warning dissemination, and evacuation transportation—all of which significantly influence how people respond to rapid onset disasters. Consequently, many well-established propositions about behavioral response must be treated as tentative in the context of a developing country (CDRSS, 2006).

In addition, recent studies of other environmental threats, such as hurricanes and earthquakes, have developed better measures of psychological variables such as expected personal consequences (Huang et al., 2012, 2017) and affective reactions (Lindell et al., 2016; Wei & Lindell, 2017) to explain people's immediate behavioral responses. Consequently, these measures should be added to variables such as situational context, warning source, and warning content that have previously been addressed in flood warning studies.

These considerations are represented graphically in Figure 1, which depicts the relationships among seven sets of key variables from the PADM that were examined in this study. This figure implies eight research objectives, the first four of which examine the effects of demographic characteristics, flood evacuation experience, preimpact emergency preparedness, and situational context on information sources, psychological reactions, and behavioral responses.

[Figure 1 about here]

- RO1: To assess the effects of demographic characteristics on information sources, psychological reactions, and behavioral responses.
- RO2: To assess the effects of previous flood evacuation experience on information sources, psychological reactions, and behavioral responses.
- RO3: To assess the effects of preimpact emergency preparedness on information sources, psychological reactions, and behavioral responses.
- RO4: To assess the effects of situational context on information sources, psychological reactions, and behavioral responses.

The next three research objectives examine the degree to which information sources, psychological reactions, and behavioral responses form the causal chain predicted in Figure 1.

- RO5: To assess the effects of information sources on psychological reactions and behavioral responses.
- RO6: To assess the effects of psychological reactions on behavioral responses.
- RO7: To test whether psychological reactions mediate the relationships between information sources and behavioral responses.

The last research objective examines the degree to which three of the behavioral responses can be predicted from information sources, psychological reactions, and antecedent variables, as well as the hypothesized mediation effect of psychological reactions.

- RO8: To identify the best predictors of people's first response, final response, and evacuation delay.

2.0 Background and Method

2.1 The Event

The North Indian state of Uttarakhand, which is located at the foothills of the Himalayan mountain range, has a total geographic area of 51,125 km², of which 93% is mountainous and 65% is covered by forest. It is the 20th most populous state in India (out of 28 states and seven union territories), with a population of 10,116,752 (male = 51%; female = 49%) accounting for 0.84% of India's 1.2 billion population (Census of India, 2011). Uttarakhand shares international borders with China to the north and Nepal to the east and is fondly referred to as *Dev Bhumi* (God's land) by Hindus. Two of the most revered Indian rivers, the Ganga and the Yamuna, originate in the Gangotri and Yamunotri glaciers in the Uttrakashi district of the state. The four towns of Badrinath, Kedarnath, Gangotri and Yamuntri form the *Chota Char Dham* ("the small circuit of four abodes/seats"), a renowned Hindu pilgrimage circuit. As such, this region is considered hallowed ground for Hindus from India and other parts of South Asia. Tourism statistics for the state counted 30 million tourists in 2010 (Arlikatti et al., 2018).

The cause of the 2013 Uttarakhand disaster is attributed to compounding reasons starting with widespread heavy rainfall between 15-18 June throughout the 13 districts of the state. As per the Indian Meteorological Department (IMD), the rainfall in the State measured during this period was "385.1 mm, against the normal rainfall of 71.3 mm, which was in excess by 440%" (NIDM 2014, pg. 70). This likely caused the melting of the Chorabari Glacier at a height of 3800 meters in the Garhwal Himalayan region, further increasing runoff, causing numerous rivers to swell, change their course and overtopping of dammed lakes. This resulted in devastating flash floods and landslides, especially in the Mandakini Valley of the Rudraprayag district and the moniker "Himalayan tsunami" (NIDM 2014, pg. 74) by the Indian newsmedia.

2.2 Sample

In October 2013, flood survivors were sought in 17 villages and/or government and nonprofit sponsored shelters in the Rurdraprayag district of Uttarakhand (see Figure 2). Prospective respondents were contacted using a modified snowball sampling procedure, with some respondents being located in official shelters and these interviewees suggesting additional contacts. A local trekking guide, NGO representative, or local resident was also hired at each locale to assist the team in identifying flash flood survivors. The 316 respondents were generally representative of their geographical area with respect to rural population (95.9% in the Rudraprayag District and 100% in the sample), literacy rate (81.3% and 74.1%, respectively), and Hindu religion (99.1% and 99.4%, respectively). However, there was an under-representation of females (52.7% and 41.5%, respectively) and an over-representation of respondents from the scheduled castes/tribes, which are groups that are designated by India's Constitution as historically disadvantaged people from the lowest socio-economic strata in India—sometimes informally called "untouchables" (19.8% vs. 39.5%, respectively). The median age of the respondents was 40.0 (SD = 15.5). Table III provides a description of the respondents' demographic and experiential characteristics.

[Figure 2 about here]

[Table III about here]

2.3 Measures

The US researchers drafted a questionnaire, after which an Indian researcher reviewed it, substituted locally appropriate terms and spellings, and translated it to Hindi, the local language. The questionnaire was independently back-translated to English and approved by the University of North Texas Institutional Review Board.

2.2.1 Demographic Characteristics

The questionnaire asked respondents to report their demographic characteristics—*age*, *gender* (coded male = 0, female = 1), *marital status* (coded other = 0, married = 1); how many people in their household were in different age categories—LT 18, 18-65, GT 65 (summed to compute the *household size*); *caste*; *religion*; highest level of *education* (recoded as the number of years of education), *household income*, *homeownership* (coded renter = 0, owner = 1); and community *tenure* (how long they had lived in their village). Table II lists the measures used in the analysis and the ways in which they were scored.

[Table II about here]

2.2.2 Flood Evacuation Experience and Pre-impact Emergency Preparedness

Respondents were also asked about their previous *flood evacuation experience* (no = 0; yes = 1); and which types of *emergency preparedness* items they had before the flood (water, non-perishable food, medicines, cash, change of clothes, female hygiene products, cell phone, address of safe area, other), which was analyzed as the total number of items. The evacuation preparedness items formed a scale with an internal consistency reliability of $\alpha = .80$.

2.2.3 Situational Context Variables

Respondents were also asked to report—at the time the flash flood struck—their physical context (own home; friend's or relative's home; workplace; in transit walking; at temple; in a public place; in a vehicle; or other), which was recoded as at home (= 1) or other (= 0). They were also asked about their household context (all household members together; some household members absent but in a safe location; some household members absent and known to be in danger; or some household members absent and their safety was unknown), which was recoded as household together (= 1) or other (= 0), and their social context (alone, with children under 18, with adults they knew, with adult strangers), which was recoded as children<18 (= 1) or other (= 0).

2.2.4 Information Sources

They reported the flood *noise violence* ranging from unnoticeable (= 1) to violent (= 6). The item addressing the respondent's *first source* of information about the flood had the first five options (knew torrential rain could cause a flood, saw animals behaving unusually, saw unusual changes in mountain slopes, saw many people evacuating, and saw the flood) recoded to environmental/social cues (= 0) and the second four options (warned by a village bell ringing; warned face-to-face; warned by voice telephone or text message; warned by radio or TV) recoded to social warnings (= 1). For those whose first source was some form of warning message, respondents were asked what was the *message content* they received (threat; areas affected, protective action recommendation, safe areas, sources of assistance, sources of additional information, and other). Message content was calculated as the number of checked options. They were also asked if they had been advised by anyone to evacuate to a safer location (no; authority; news media; peer; tourist). The number of *sources of evacuation recommendations* was computed by scoring no = 0 and summing the total number of evacuation recommendations from the four sources.

2.2.5 Psychological Reactions

Respondents were also asked—at the time of the flood—what were their *landslide expectations* (not certain = 1 to very certain = 5). Those who thought a landslide was possible were asked what the expected time (in hours) of *landslide arrival* was. To assess *expected personal consequences* of the flood, respondents were asked to recall the extent (not at all = 1 to very great extent = 3) to which they thought—at the time of the flood—that it would severely damage or destroy their home; injure or kill themselves and their families; disrupt their jobs and prevent them from working; disrupt electrical, telephone and other basic services; destroy or severely damage many homes in their village; injure or kill many people in their village if they did not evacuate; or place their lives and their families at risk if they did not evacuate. The expected personal consequences items were averaged to form a scale with α = .84

Respondents' affective reactions were assessed by asking the extent to which they felt optimistic, depressed, annoyed, nervous, fearful, relaxed, energetic, alert, and passive (not at all = 1 to very great extent = 3). Factor analysis of the affective reactions items revealed two factors—*positive affect* (optimistic, energetic, and alert) and *negative affect* (depressed, nervous, and fearful). The means of the three items on each factor were computed to form scales with α = .70 and .84, respectively.

2.2.6 Behavioral Responses

Respondents were asked to report their *first response* to the flash flood—continued what I was doing; stopped what I was doing but stayed where I was; protected property (all recoded to remained in place = 0); climbed to a higher level; protected persons; immediately left the building (all recoded to evacuated =1); continued driving; pulled over to the side of the road; other (not analyzed because of the small number of responses). In the sections that follow, this dichotomized version of first response is called *immediate evacuation*. They were asked to identify any other types of information they received to confirm the threat after receiving their first information about the flood (saw the flood water; saw people evacuating;

information face-to-face; phone call; radio; TV; text message; email; siren; village bell; or other). *Warning confirmation* was calculated as the total number of ways the threat was confirmed. Respondents were also asked what their *final response* to the flood threat was. Responses of stayed and continued normal activity, stayed and awaited further information, and went to see the flood water were recoded to remain at risk (= 0), whereas evacuated uphill, evacuated downhill, evacuated horizontally; and evacuated to a higher floor were recoded evacuate (= 1). In the sections that follow, this dichotomized version of final response is called *later evacuation*. Those who evacuated were asked if they tried to get *additional information* before evacuating (no; peers; authorities; news media; tourists; other), with the five sources summed to compute the extent of additional information search. Respondents were also asked if they engaged in any *evacuation preparations* (looked for separated family members, secured their property, gathered emergency supplies, warned others, or other). The number of pre-evacuation activities was computed by summing these five actions. Evacuees were also asked about their *evacuation delay* (in minutes), which was recoded to immediate evacuation (= 0) or delayed evacuation (any delay greater than or equal to one minute = 1).

2.4 Analyses

The data were analyzed to produce means/proportions for each of the questionnaire items addressed in Figure 1, thus allowing the Uttarakhand flood to be compared to the floods summarized in Table I and the other rapid onset hazards discussed in Section 1.2. Next, bivariate correlations were computed to address RO1-RO6 and logistic regression analyses were conducted to address RO7-RO8. Finally, the results of the correlation and regression analyses were compared to address the equivocality of both types of analyses. Specifically, regression analyses can be used to identify the most parsimonious model for predicting a given dependent variable in a sample. However, regression analyses need to be carefully examined because they can fail to identify other models that do not fit the data quite as well as the model in the estimation sample but might fit as well or better in cross-validation samples. Such caution is especially important when there is collinearity among the predictor variables (see Gordon, 1968; Huang, Lindell & Prater, 2016).

Moreover, the large number of variables in the correlation and regression analyses could produce an inflated experiment-wise error rate if the conventional significance level of $p < .05$ were used. Specifically, the correlation analyses yielded (28*27)/2 = 378 distinct correlations, which would yield a chance expectation of approximately 19 correlations "significant" at $p < .05$ but only about 4 correlations "significant" at $p < .01$. Thus, only correlation and regression coefficients significant at $p < .01$ are discussed below.

Finally, the test to determine whether psychological reactions mediate the relationships between information sources and behavioral responses followed the causal steps procedure described in MacKinnon, Fairchild and Fritz (2007). Specifically, the first step is to determine if information sources significantly predict psychological reactions and behavioral responses (Paths A and C in Figure 1) and the second step is to see if psychological reactions significantly predict behavioral responses (Path B). The third step is to examine whether the effect of information sources on behavioral responses becomes nonsignificant when controlling for psychological reactions (Path C becomes nonsignificant when controlling for Path B).

3.0 Results

Regarding RO1 (To assess the effects of demographic characteristics on information sources, psychological reactions, and behavioral responses), Table IV shows that the demographic variables (Columns 1-8) tended to be poor predictors of information sources (Rows 14-17), psychological reactions (Rows 18-22), and behavioral responses (Rows 23-28) because only four (3%) of the 120 correlations were statistically significant. The most notable of these was the significant negative correlation of female gender with positive affect (r = -.23). In addition, people having more years of education engaged in more pre-evacuation activities (r = .18), those with higher incomes received more complete warning message content (r = .24), and households with longer tenure received evacuation recommendations from fewer sources (r = -.16).

[Table IV about here]

Regarding RO2 (To assess the effects of previous flood evacuation experience on information sources, psychological reactions, and behavioral responses), almost none of the respondents had previous flood (1.9%) or flood evacuation (0.2%) experience, or had attended flood or landslide meetings (1.9% and 3.2%, respectively) or received flood or landslide brochures (1.6% and 2.8%, respectively). Nor did many of them have a significant level of pre-impact emergency preparedness—Table IV indicates that the latter variable had a median of one item from a list of 12 items (39% had none of the items). Moreover, flood evacuation experience (Column 9) was also a weak predictor, having only one (7%) of the 15 correlations with information sources, psychological reactions, and behavioral responses being statistically significant (r = .18 with message content). However, the analysis of RO3 (To assess the effects of preimpact emergency preparedness on information sources, psychological reactions, and behavioral responses) revealed that pre-impact emergency preparedness (Column 10) was a significant predictor of six (40%) of the 15 variables—evacuation warning sources (r = .27), landslide expectations (r = .15), and all three milling behaviors (information search, warning confirmation, and evacuation preparations—average r = .35). Ultimately, however, pre-impact emergency preparedness seems to have had a somewhat negative effect because it was related to longer evacuation delays (r = .16).

The analyses associated with RO4 (To assess the effects of situational context on information sources, psychological reactions, and behavioral responses) showed that there was moderate diversity in respondents' physical context; 69.6% of the respondents were at home, 19.3% were at work, 4.4% were in transit to/from work, 2.5% were at a friend's home, and the rest were at other places at the time of the flood. Regarding their household context, 54.7% were with all family members at home, 21.2% had some family members absent but in a safe location, 19.9% had some family members absent and in danger, and 4.4% had some family members absent and whereabouts uncertain. With regard to their social context, 56.3% were with children under 18 years, 55.7% were with adults they knew, 13.7% were alone, and only 2.2% were with adult strangers. However, the situational context variables (Columns 11-13) had significant positive correlations with each other (average r = .34) and six (13%) significant correlations out of 45 correlations with information sources, psychological reactions, and behavioral responses. Household together was correlated with violent noise (r = .19) and later evacuation (r = .30), whereas social context (with a child less than 18) was positively related with landslide expectation (r = .15), information search (r = .18), warning confirmation (r = .17), and evacuation delay (r = .16).

The analyses associated with RO5 (To assess the effects of information sources on psychological reactions and behavioral responses) showed that the majority (82.1%) rated the flash flood sound as violent and many of the rest rated it as strong (8.0%). The first information source for the majority (67.4%) was an environmental cue such as the flood water (37.0%), heavy rain that they knew could cause a flash flood (23.1%), changes in mountain slopes (5.4%), or unusual animal behavior (1.9%). A minority were warned by social cues—seeing others evacuate (3.2%)—or by warning messages received face-to-face (16.1%), by phone voice/text (9.5%), or by radio, TV, village bell or other sources (3.8%). In general, warning message content provided limited information; 82.3% said their warning message described the threat but only a few messages contained a protective action recommendation (15.5%), information about a safe place to go (12.0%), or the threat location (6.0%). Less than 1% of the respondents reported that the warning message indicated sources of further information or assistance. Overall, 90% of the messages contained only one element, 6% contained two elements, 2% contained three elements, and 2% contained four elements. Regarding evacuation message sources, 58.7% received no evacuation warning, 26.7% received an evacuation warning from peers, 10.5% received one from an authority, and 4.1% received one from other sources; no one received one from the news media.

Overall, the information sources (Columns 14-17) had nine (20%) significant correlations out of 44 correlations with psychological reactions, and behavioral responses. Violent noise was correlated with landslide expectation (r = .15), expected personal consequences (r = .21), and negative affect (r = .25), whereas message content was positively related with warning confirmation (r = .32), and evacuation source was positively correlated with information search (*r* = .37), warning confirmation (*r* = .22), and evacuation preparation (*r* = .23).

The analyses associated with RO6 (To assess the effects of psychological reactions on behavioral responses) showed that psychological reactions (Columns 18-22) were quite variable. Figure 3 indicates that expected personal consequences were strongest for expected disruption to community services (*M* = 2.8) and their jobs (*M* = 2.7), destruction of others' homes (*M* = 2.6), and loss of life to others in the community (*M* = 2.6). They also had strong expectations of danger to themselves if they did not evacuate (*M* = 2.7), damage/destruction of their own homes (*M* = 2.5) and injury or death to themselves and their families (*M* = 2.1). Moreover, respondents' affective responses (*Not at all* = 1 to *Very great extent* = 3) were more negative—depressed (*M* = 2.7), nervous (*M* = 2.8), and fearful (*M* = 2.8)—than positive—optimistic (*M* = 2.0), energetic (*M* = 2.2), and alert (*M* = 2.4).

[Figure 3 about here]

Although 32.0% of the respondents were very certain of a landslide (= 3), 16.1% were quite certain (= 2), and 51.9% were not certain (= 1). As Figure 4 indicates, 28.9% of respondents believed a landslide would strike within 30 minutes, whereas other respondents believed a landslide would strike as quickly as 2 hours (21.7%) or as late as 5 days or more (26.3%).

[Figure 4 about here]

The psychological reactions variables had 11 (37%) significant correlations out of 30 correlations with behavioral responses. Landslide expectation was correlated with warning confirmation (*r* = .16), evacuation preparation (*r* = .16), and later evacuation (*r* = .15), whereas landslide arrival was positively related with immediate evacuation (*r* = .15), and negatively related with warning confirmation (*r* = -.17), and later evacuation (*r* = -.23). In addition, expected personal consequences was correlated with immediate evacuation (*r* = .20) and later evacuation (*r* = .23), positive affect was positively related with later evacuation (*r* = .23).

As noted earlier, the test of RO7 (To test whether psychological reactions mediate the relationships between information sources and behavioral responses) requires that 1) information sources significantly predict psychological reactions and behavioral responses (Paths A and C in Figure 1), 2) psychological reactions significantly predict behavioral responses (Path B), and 3) the effect of information sources on behavioral responses becomes nonsignificant when controlling for psychological reactions (Path C becomes nonsignificant when controlling for Path B). Examination of Table IV shows that violent noise is significantly related to landslide expectations, expected personal consequences, and negative affect (the psychological reactions) and first response and final response (the behavioral responses), so those are the only variables that satisfy Condition 1. Moreover, landslide expectation is significantly related to warning confirmation, evacuation preparation, and final response; expected personal consequences are significantly related to first response and final response; and negative affect is significantly related to final response, so those are the only variables that satisfy both Conditions 1 and 2. Thus, the only remaining analyses needed to test mediation effects are the regression of first response onto violent noise and expected personal consequences; regression of first response onto violent noise and expected personal consequences; the regression of final response onto violent noise and expected personal consequences; and the regression of final response onto violent noise and negative affect. Table V reveals that expected personal consequences completely mediated the effect of violent noise on first response because the regression coefficient for violent noise was $p > .01$ when controlling for expected personal consequences. However, expected personal consequences and negative affect only partially mediated the effect of violent noise on first response because the regression coefficient for violent noise was $p < .01$ when controlling for both of these variables.

[Table V about here]

Regarding RO8 (To identify the best predictors of people's first response, final response, and evacuation delay), one can assume that people's first response will significantly influence their final response, so Table VI cross-tabulates these two variables. The first row of the table indicates that there were very few people (17/314 = 5.4%) whose first response was to continue what they were doing, so there were nonsignificant differences in the percentages of those who engaged in the three most common responses—stayed and continued their previous activities, went to see the water (presumably to assess the threat), and evacuated uphill. There were more people (37/314 = 11.8%) who initially stopped what they were doing and stayed where they were. Some of these people ultimately stayed where they were and continued their activities (8/37 = 21.6%) or awaited further information (8/37 = 21.6%), but many more evacuated uphill (16/37 = 43.2%). Those who engaged in the remaining first responses (stopped and climbed, protected persons, protected property, immediately left the building, pulled over to the roadside, and other) overwhelmingly evacuated uphill (percentages range 50.0-91.9%).

[Table VI about here]

Evacuation departure delays were caused, in part, by attempts to obtain additional information from peers (35.1%), authorities (7.3%), and news media (2.2%), but 58.9% sought no additional information. Evacuations also were delayed by people's attempts to locate family members (25.0%), protect property (25.3%), pack an emergency kit (18.4%), or warn others (45.6%). Moreover, 73.4% of the respondents had the threat confirmed by seeing the flood coming, 29.7% saw people evacuating, 16.5% received additional information by phone, 10.4% received information face-to-face, and 2.5% heard a siren alert. Less than 3% received information by radio or TV and none received it by text, email, or village bell. Many of the respondents engaged in some evacuation preparations; 25% looked for separated family members, 25% secured their property, 18% gathered some emergency supplies, and 46% warned others. Consequently, their departure timing was skewed, ranging from 30 minutes or less (53.4%) to more than 5 days—although 84.7% of them left within 240 minutes. As indicated in Figure 4, respondents generally evacuated about 60 minutes before their expected time of landslide arrival.

The three milling behaviors—warning confirmation, information search, and evacuation preparation—all had significant positive correlations with each other (average $r = .35$). These three variables were also significantly correlated with pre-impact emergency preparedness (average $r = .37$) and the number of evacuation warning sources (average $r = .27$). Moreover, information search and warning confirmation activity were significantly correlated with child under 18 ($r = .18$ and .17, respectively), and the latter variable was also significantly correlated with message content ($r = .32$), landslide expectation ($r = .16$), and expected landslide arrival time ($r = -.17$).

The best-fitting model for immediate evacuation can be seen in the left panel of Table VII, which shows that household together ($b = .73$), violent noise ($b = .23$), information search ($b = -.75$), expected personal consequences ($b = .72$), and positive affect ($b = .81$) were its best predictors. The middle panel shows that household together ($b = 1.15$), evacuation preparation ($b = .85$), and immediate evacuation ($b = 3.01$) were the best predictors of a later evacuation. The right panel shows that information search ($b = .97$) and positive affect ($b = .80$) were the best predictors of evacuation delay.

[Table VII about here]

4.0 Discussion

In order to see if the flood response in India differs systematically from that in North American and Europe, it is instructive to compare the univariate results from the Uttarakhand survey to the results from the studies cited in Table I. In addition, the 2009 Samoa tsunami is relevant because it was a rapid onset hydrological hazard and the questionnaire was quite similar to the one used in Uttarakhand (Lindell et al., 2015). Other suitable points of comparison addressed below are the 2011 earthquakes in Christchurch New

Zealand and Hitachi Japan that produced tsunami threats (Wei et al., 2017) and the 2010 Boston water contamination incident (Lindell et al., 2017).

4.1 Comparison of the Responses in Uttarakhand and Other Rapid Onset Events

The Uttarakhand residents had very low levels of flood evacuation experience and emergency preparedness and had received little information about flood and landslide hazards either through meetings or brochures (less than 5%)—all of which were comparable to data from Lindell et al. (2015) and Wei et al. (2017). Although one might assume that these factors would be impediments to evacuation, the analyses below suggest this was not the case for flood experience but there was a slight effect for emergency preparedness. However, respondents were more likely to be at home (70%), have household members together (55%—compared to 94-99% in Perry et al., 1981), and have other adults present (56%). All of these situational contextual factors eliminate common barriers to evacuation.

The Uttarakhand flood's rapid onset caused the majority of households to be warned by environmental cues (67%), which was even higher than the maximum (50%) of the other flood sites in Table I at which data on environmental cues were collected. Conversely, Uttarakhand had an extremely low rate of warning by authorities (<1%), which was essentially tied with the minimum (both 0%) and well below the median (20%) for the other flood sites in Table I. In addition, Uttarakhand also had an extremely low rate of warning by the news media (<1%) that was also well below the median (20%). Finally, Uttarakhand had a moderate rate of warning by peers (29%) that was well above the minimum (14%), but below the median (38%). This result calls attention to the need for future research to examine warning recipients' physical proximity to peers and connections to social networks (as well as access to telephones) to better understand the relative percentages who receive face-to-face warnings or telephone warnings from peers. It will be especially important to assess the importance of such communication channels across communities (e.g., urban vs. rural) within countries and also between countries.

For those who received a warning, some aspects of message content were similar to other disasters, whereas other aspects were different. Specifically, the percentages of warning messages in the 2013 Uttarakhand flood, the 2009 Samoa tsunami, and the 2011 Boston water contamination incident that identified the threat were 82, 46, and 82%, respectively. The percentages of messages containing a protective action recommendation were 16, 35, and 76%, respectively; the percentages of messages providing information about a safe place to go were 12, 49, and 9%, respectively; the percentage indicating the threat location were 6, 26, and 52%, respectively; and the percentage providing sources of further information or assistance were 1, 16, and 10%, respectively. Given the differences in the results for the other two events, the content of the Uttarakhand cannot be said to differ in any systematic respects. The most notable pattern is that the warnings in the Boston water contamination incident identified a protective action recommendation, presumably because the protective action recommendation—boiling water—would not necessarily be obvious to all warning recipients. By contrast, evacuation would be the obviously appropriate protective action for the flash floods and tsunamis. Similarly, identification of the threat location was more important for the water contamination incident because this hazard provided no environmental cues equivalent to proximity to the coast (for the tsunami) or to the nearest river (for the flash flood).

Fewer people in Uttarakhand than in Samoa received additional information from others face-to-face (10% vs. 41%, respectively) or by phone (17% vs. 29%, respectively). The face-to-face percentage for Uttarakhand, but not Samoa, is smaller than reported in Christchurch (62%) and Hitachi (50%), which suggests that earthquake shaking as an environmental cue to tsunami onset affects the channels of warning confirmation. However, the phone percentages for both Uttarakhand and Samoa are smaller than in Christchurch (73%) and Hitachi (45%), which casts doubt on this interpretation. Future research should ask if the respondent had access to a working telephone to determine if this accounts for differences in the rates of telephone warnings.

Less than 3% of Uttarakhand residents received additional information by radio or TV, compared to 55% by radio and 4% by TV in Samoa. The comparable percentages in Christchurch (48% for radio and 7% for TV) and Hitachi (37% and 14%, respectively) clearly indicate a consistently lower level of confirmation by the news media in Uttarakhand than in the other three sites and the latter three sites indicate a consistently higher level of confirmation by radio than by TV. In this case, also, the environmental cue provided by earthquake shaking gave people in the news media at the three tsunami sites a greater opportunity to transmit warnings. None of those in Uttarakhand received additional information by text (vs. 2% in Samoa) or email (vs. 1% in Samoa)—primarily because the torrential rains and flash flooding destroyed major power lines, roads, bridges and other critical infrastructure including cell phone towers. Many villages in the district were without power for months after the disaster (Arlikatti et al., 2018).

In addition, there were more people in Uttarakhand than in Samoa that received no evacuation warning (59% vs. 11%) due to the rapid flood onset and the hilly terrain with isolated and sparsely populated villages. However, a comparable percentage received an evacuation warning from peers (30% in Uttarakhand vs. 36% in Samoa), and smaller percentage received one from an authority (13% vs. 32%, respectively) or the news media (1% vs. 19%, respectively).

After they received their first information about the flood, the overwhelming majority of residents in Uttarakhand (70%) received threat confirmation by seeing the oncoming water. This is a far larger percentage than in Samoa (9%), let alone the other flood sites in Table I (0%). The differences between the Uttarakhand and Samoa incidents in the percentage seeing the oncoming hazard can be explained by the fact that there was a 15 minute time lag in Samoa between the earthquake shaking and tsunami wave arrival.

This made it possible for those at risk in Samoa to receive social warnings and begin evacuating well before the tsunami struck. By contrast, the roar of the flash flood water would have been audible to Uttarakhand residents only minutes before its arrival. As Figure 2 indicates most respondents were from villages situated on the banks of rivers, so there was much less time for informal peer networks to disseminate warnings before hazard onset.

The Uttarakhand residents had extremely high levels of expected personal consequences, with ratings ranging from 55-90% of the range of the response scale. For example, the average rating of community service disruption (M = 2.8) is 90% of the range of the response scale (from "1" to "3"). By contrast, the ratings of expected personal consequences only ranged 65-79% of the response scale range in the Samoa tsunami threat, 39-58% in Hitachi for the Tohoku tsunami threat, and 25-39% in the Christchurch tsunami threat. Uttarakhand residents also had extremely high levels of affective response, with ratings ranging from 52-68% of the response scale range for positive affect and 87-91% for negative affect.

The large percentage of those in Uttarakhand whose threat was confirmed by seeing flood water made it unsurprising that the percentage of those who received confirmation from authorities or news media (3% and 3%, respectively) was below the minimum for the other flood sites (5% and 24%, respectively). Finally, the percentage of people who received confirmation from the peers in Uttarakhand (30%) was slightly above the median for the other flood sites (27%) but below their maximum (42%). Uttarakhand's differences from other flood sites in Table I with respect to the sources of threat confirmation can clearly be explained by the absence of official warnings, which caused environmental cues to be the primary initial source of threat information.

In addition, residents of Uttarakhand were similar to those in Samoa regarding their attempts to obtain additional information from peers (35% vs. 24%, respectively), authorities (7% vs. 12%, respectively), and news media (2% vs. 16%, respectively). Interestingly, the relative percentages for the three types of sources were more similar in Samoa than in Uttarakhand for both evacuation warnings and additional information. Similar to the case for information channels, it is unclear if this result is due to Uttarakhand respondents perceiving greater differences among the sources in their credibility or their accessibility, so further research is needed to address this issue.

Moreover, evacuation preparations were also similar in Uttarakhand and Samoa with respect to people's attempts to locate family members (25% vs. 37%, respectively), pack an emergency kit (18% vs. 26%, respectively), warn others (20% vs. 20%, respectively), or help others (2% vs. 2%, respectively). However, Uttarakhand households were more likely to protect property (25% vs. 4% in Samoa). This difference might be due to beliefs about the feasibility of protecting property located along the hilly slopes or plateaus from rising flood water as compared to property on the coastal plains from a tsunami wave. Moreover, the Uttarakhand data on relaying warnings to others were almost identical to the corresponding England/Wales data, which indicated that 22% of respondents relayed flood warnings to neighbors and 18% relayed these warnings to relatives (Parker et al., 2007b).

Ultimately, the final responses of Uttarakhand residents were similar to those of Samoa residents. The overwhelming majority in both locations evacuated (80% vs. 66%, respectively), whereas much smaller percentages waited for further information (7% vs. 17%, respectively), continued normal activities (8% vs. 13%, respectively), or moved closer to the hazard (5% vs. 1%, respectively). Paradoxically, there was more extensive evacuation in these two locations that lacked sirens than in Cesenatico, Italy where a siren warning prompted 29% of residents to warn others, 23% to seek further information, 21% to protect property, 18% to continue normal activities, and only 2% to prepare to evacuate (Pescaroli & Magni, 2015). The lack of prompt evacuation in response to sirens in Cesenatico is consistent with the findings from previous studies in Hawaii (Lachman et al., 1960; Gregg, et al., 2007). Taken together, the results from Uttarakhand, Samoa, Cesenatico, and Hawaii suggest that environmental cues are more immediately effective than sirens, probably because environmental cues are distinctively related to their associated hazards, whereas sirens only provide a general alert that "something is wrong" (Perry et al., 1981).

4.2 Correlation Results

The results for RO1 (To assess the effects of demographic characteristics on information sources, psychological reactions, and behavioral responses) show that the findings for flash floods are consistent with those from hurricane evacuation (Baker, 1991; Huang et al., 2016) and earthquake hazard adjustment (Lindell, 2013; Lindell & Perry, 2000) in demonstrating that demographic characteristics have small correlations with behavioral responses. In addition, this study indicates that demographic characteristics have small correlations with information sources and psychological reactions. The only set of variables with which demographic characteristics had a reasonable number of significant correlations was situational context (6/24 = 25% of the correlations).

The results for RO2 (To assess the effects of previous flood experience on information sources, psychological reactions, and behavioral responses) were just as weak as those for RO1 because flood evacuation experience had only one (7%) significant correlation—with message content—of the 15 that were tested. The nonsignificant correlation of flood evacuation experience with behavioral response conflicts with the Four Community study's finding of a significant negative correlation but is consistent with the Huang et al. (2016) meta-analysis of hurricane evacuation studies that found a nonsignificant average effect size for this variable. The conflicting results can be explained by Baker's (1991) proposition that the effect of experience depends on the lessons that people learn from that experience—a conclusion that has subsequently been supported by Lindell and Hwang (2008) and Demuth et al. (2016).

The results for RO3 (To assess the effects of preimpact emergency preparedness on information sources, psychological reactions, and behavioral responses) are substantially more supportive than those for previous evacuation experience, with six (40%) of 15 correlations being statistically significant. Interestingly, preimpact emergency preparedness was not significantly correlated with immediate evacuation and later evacuation but had large correlations with milling behaviors—information search, warning confirmation, and evacuation preparation. Unfortunately, the ultimate effect of this milling was to increase evacuation delay. There do not appear to have been any other studies that have examined the effect of emergency preparedness on behavioral response to floods, but emergency preparedness has been found to be positively correlated with appropriate behavioral response to earthquakes (Lindell et al., 2016) and expectations of evacuating from flooding (Morss et al., 2016).

The results for RO4 (To assess the effects of situational context on information sources, psychological reactions, and behavioral responses) showed only slightly better than chance association with behavioral responses (4/45 = 9% of the tested correlations were significant). This is quite similar to the 10% that has been reported to affect behavioral response to earthquakes (Lindell, 2012; Lindell et al., 2016). In particular, the presence of children under 18 has the most consistent effect on behavioral response to rapid onset hazards.

The results for RO5 (To assess the effects of information sources on psychological reactions and behavioral responses) revealed that violent noise had the most consistent correlations with psychological reactions and behavioral response—especially people's immediate evacuation and their later evacuation. This result is similar to the finding from the Samoa earthquake and tsunami that those who experienced more intense shaking evacuated more rapidly to higher ground. By contrast, the number of sources recommending evacuation had consistently strong correlations with all three milling behaviors—information search, warning confirmation, and evacuation preparation. These results suggest that violent noise provided a directly interpretable indication of severe and imminent threat that required immediate protective response, whereas evacuation recommendations were more equivocal; the appropriate response to these information sources depended on the warning recipients' judgments of the warning sources' credibility.

The results for RO6 (To assess the effects of psychological reactions on behavioral responses) were relatively strong, with 11/30 (= 37%) of the tested correlations being statistically significant. Specifically, stronger expectations of landslides produced more milling and a greater probability of finally evacuating. These results are similar to those from the 2011 Christchurch earthquake, where expectation of an earlier tsunami arrival increased the probability of evacuation, but are inconsistent with results from Hitachi residents in the 2011 Tohoku earthquake or the Samoa earthquake and tsunami, where the correlations were not significant.

In addition, expectations of earlier landslide arrival produced earlier evacuations. These results are similar to those from the Samoa earthquake and tsunami, where expectation of earlier tsunami arrival prompted earlier evacuation. Greater expectations of personal consequences and negative affect were associated with evacuation as both an initial and final response, a result that is similar to findings from the 2011 Christchurch earthquake and Hitachi residents in the 2011 Tohoku earthquake, where expected personal consequences were associated with a higher probability of evacuation. They are also similar to findings from the Samoa earthquake and tsunami, where expectations of personal consequences were associated with decreased evacuation delay, although they were unrelated to evacuation.

4.3 Regression Results

The mediation analysis testing RO7 (To test whether psychological reactions mediate the relationships between information sources and behavioral responses) confirms that expected personal consequences was the only psychological reaction that significantly mediated the relationship between any of the information sources (violent noise) and first response. Moreover, the mediation was complete; that is, violent noise had a nonsignificant effect when expected personal consequences were controlled. By contrast, both expected personal consequences and negative affect significantly mediated the relationship between violent noise (the only significant information source) and final response. However, this mediation was only partial; that is, violent noise still had a significant effect when expected personal consequences were controlled. This indicates that violent noise either had a direct effect on final response or that it affected some other variable that, in turn, directly affected final response. Future research should examine whether there is another variable, in addition to expected personal consequences, that mediates the relationship between violent noise and final response.

Regarding RO8 (To identify the best predictors of people's immediate evacuation, later evacuation, and evacuation delay), the Uttarakhand study differs from the Rapid City (Mileti & Beck, 1975) and Four Community (Perry et al., 1981) studies in distinguishing among three different dependent variables—first response, final response, and evacuation delay. The regression analysis of these three dependent variables yielded similar results for immediate evacuation and evacuation delay; the two significant predictors were positive affect and information search for both dependent variables. The significant regression coefficient for positive affect is somewhat surprising because one would expect that negative affect, due to expected personal consequences, would be the affective reaction that influences behavioral responses. However, the three items used to measure positive affect—optimistic, energetic, and alert—suggest that this scale was measuring a construct similar to *self-efficacy*, which has been found to be an important predictor of behavior in studies of Protection Motivation Theory. That is, respondents were more likely to evacuate immediately if they thought they had an ability "to actually carry out the adaptive response" (Floyd et al., 2000, p. 411).

This explanation is supported by the finding that positive affect was unrelated to violent noise (r = .05) but was related to male gender (r = -.23). This finding is broadly consistent with Trost et al. (2003), who reported that male gender and self-efficacy are correlated with higher levels of physical activity, although it was not reported if they are correlated with each otehr.

The significant regression coefficients for information search are interesting because this variable had a negative effect on immediate evacuation (because it substituted for evacuation) and a positive effect on evacuation delay (because information seeking takes time). By contrast, the regression results for the prediction of later evacuation showed that immediate evacuation and household together were the two significant predictors. There do not appear to have been any other flood studies that reported the relationship between immediate evacuation and later evacuation, but household together was a stronger predictor of later evacuation in Uttarakhand than in Rapid City.

In most respects, the Uttarakhand results seem to be quite different from the Rapid City and Four Community study results because Mileti and Beck (1975) reported that warning content ("specific own-area warning"), communication mode ("person-specific" warnings such as telephone or face-to-face), and warning belief were relatively strong predictors of warning response. Moreover, Perry et al. (1981) reported significant regression coefficients for perceived threat (Mileti and Beck's "warning belief"), personal risk (expected flood severity), adaptive plan (knowledge of an evacuation mode, route, and destination), past flood experience, contacts with relatives, contacts with friends and neighbors, and age. None of these variables appeared as significant predictors in the Uttarakhand results.

One explanation for the difference in significant predictors of warning response between the Uttarakhand results and the other two studies is that these three studies included somewhat different sets of variables in their prediction equations. For example, Mileti and Beck included warning content, communication mode, and situational context in their prediction of warning response but Perry et al. did not. Conversely, Perry et al. included personal risk, adaptive plan, past flood experience, contacts with relatives, contacts with friends and neighbors, and age, but Mileti and Beck did not. This is potentially problematic because a variable's regression coefficient can differ from one study to another, depending on which other variables are controlled (see the discussion of omitted variables in James et al., 19810.

A second explanation for differences among the three studies' results is that, even when some of the studies had variables in common, some of the variables were measured in different ways. For example, Perry et al. measured personal risk by asking respondents to rate the severity (none, slight, moderate, severe) of "damage to my property and possibly my family". This is noticeably different from the Uttarakhand study's seven item measure of expected personal consequences.

A third explanation is that sampling fluctuations can allow a predictor variable to emerge with a significant regression coefficient because it has a slightly higher, but not significantly different, correlation with the dependent variable. In the Uttarakhand model for immediate evacuation, positive affect and information search are the best predictors (among those variables specified in Table VI). However, although these variables are the best predictors *in this sample*, these results should be considered tentative because the 95% confidence interval (N = 316) for the correlation of positive affect (r = .21), the variable with the highest correlation with immediate evacuation, is $.10 \le r \le .31$. Thus, at home (-.14), household together (.14), violent noise (.18), landslide arrival (.15), and expected personal consequences (.20) all have correlations that are nonsignificantly different from that of positive affect. In turn, that means that a variety of models with different combinations of these variables would have approximately the same degree of fit in this sample and, therefore, might fit just as well or better in future samples.

By contrast, the best predictor for later evacuation is immediate evacuation (r = .49), so immediate evacuation should clearly be included in any model predicting later evacuation because its 95% confidence interval ($.40 \le r \le .57$) does not include any of the other predictors of later evacuation. However, the 95% confidence interval for the correlation of household together (r = .30), the variable having the next highest correlation, is $.20 \le r \le .40$. Thus, violent noise (.25), landslide expectation (.15), expected personal consequences (.23), negative affect (.23), and evacuation preparations (.26) all have correlations that are nonsignificantly different from that of household together. Thus, any one of them should not be ruled out as additional predictors of later evacuation.

Finally, for the predictors of evacuation delay, the 95% confidence interval for the correlation of information search (r = .26), the variable having the highest correlation with evacuation delay, is $.16 \le r \le .36$. Thus, emergency preparedness (r = .18), child under 18 (r = .16), violent noise (r = .18), landslide arrival (r = -.23), and positive affect (r = .20) all have correlations that are nonsignificantly different from that of information search. Accordingly, none of them should be ruled out as predictors of evacuation delay.

4.4 Theoretical Implications

Overall, results from the Uttarakhand flood survey suggest that the PADM should be considered more than a tentative framework for examining household responses to flash floods in India. Specifically, the study results support the conclusion that a household's first warning source is a function of two distinct detection and dissemination systems within a community—an official system (Mileti et al., 1975) and an informal system (Parker & Handmer, 1998; Parker et al., 2009). The official system can provide a substantial amount of forewarning for slow onset hazards, such as hurricanes, in which it rarely needs to be supplemented by the informal system (e.g., Huang et al., 2012, 2017). This is not to say that informal communication networks are inactive during hurricanes, just that they are rarely the first warning source. For example, Demuth et al. (2018, p. 543) found that most of the tweets they analyzed were responding indirectly to official information (e.g., "Most of these mentions were implicit, in that no specific forecast products or sources were named, yet the tweets indicate that the Twitterers had obtained some type of forecast information.").

Moreover, the official system can even provide a significant amount of forewarning for some rapid onset disasters, such as flash floods, when it is based on advanced detection systems (e.g., weather radar, rain gages, stream gages, and stream spotters, with each successive type of device providing less forewarning). Official system warnings can typically be disseminated rapidly via the news media (e.g., commercial radio and TV, tone alert radio) or, even more rapidly, via technologies that directly link authorities to the risk area population (e.g., wireless emergency alerts, Bean et al., 2015). In the absence of broadcast or personalized electronic dissemination technology, informal peer networks can disseminate warnings more slowly by telephone voice or text, or face-to-face warnings. When sophisticated detection and dissemination systems are absent (or when they fail—see Gruntfest, Downing & White, 1978), personal observation of environmental cues (actual flooding or knowledge that intense rainfall is likely to cause it) is the default method of detection and the peer warning network is the default method of dissemination. In the case of Uttarakhand, the rapid onset of flooding that had a life threatening depth and speed of flow, coupled with the lack of an advanced technological detection and dissemination system, overwhelmed the capacity of the peer network and left most local residents with only their own personal observation of environmental cues to alert themselves to danger. Reports in leading newspapers suggest that the majority who perished or went missing from the flash floods or landslides were religious tourists from other states such as Uttar Pradesh, Rajasthan, Punjab, Andhra Pradesh or countries such as Nepal (Talwar 2016). It is possible that they perished because they failed to properly interpret the available environmental cues due to inadequate mental models of flash floods (Lazrus et al., 2015; Morss et al., 2015; Wagner, 2007), compared villagers who are longtime residents in this mountainous terrain.

In addition, this study identified numerous other findings supporting PADM propositions. The Uttarakhand data show that environmental and social cues, as well as message content that social sources transmitted through different channels, are correlated with people's perceptions of the flash flood threat and, in turn, their information search and behavioral response. The support for the PADM is strongest in the relationship between psychological reactions and behavioral responses but is significantly weaker in the relationship between information sources and psychological reactions—where only the environmental cue (violent flood noise) had a significant correlation. This result might be due to the relatively low levels of social warnings in this event, compared to other floods and rapid onset events discussed in the previous sections.

Another set of results consistent with the PADM was that the three milling behaviors, which were significantly correlated with each other, were not significantly correlated with immediate evacuation but did have some significant correlations with later evacuation and evacuation delay. In addition, the milling behaviors generally were correlated with different information sources and psychological reactions than immediate evacuation and later evacuation. These results indicate that the PADM is correct in distinguishing between information search and protective response, but also that it needs to more clearly distinguish the antecedents of these two types of behavioral responses.

In addition, this study supports the PADM by providing evidence that perceived risk, when measured as expected personal consequences, is significantly correlated with affective responses (Lindell et al., 2015; Wei & Lindell, 2017) and both are correlated with evacuation and departure timing (Wei et al., 2017). However, these data fail to support the PADM's prediction that social context influences information sources. This might be due to the Uttarakhand flood's rapid onset, which meant that most people's first information source was an environmental cue so there was relatively little variation on this variable.

These data suggest that the PADM needs an expanded conception of pre-impact emergency preparedness. Although one would think that such preparedness would decrease (i.e., be negatively correlated with) the need for pre-evacuation preparations, the correlation turned out to be positive. This finding suggests that stockpiling emergency supplies, the measure of emergency preparedness used here, does not provide adequate preparation for a speedy evacuation. In addition to preparing for survival after a disaster, households in areas prone to flash floods and other rapid onset disasters such as near-field tsunamis should develop family evacuation plans that ensure those in the risk area can promptly recognize environmental cues and avoid spending an excessive amount of time in milling behaviors. They should also develop procedures to ensure that separated household members receive timely and comprehensive warnings and that they can reunite in a safe location as outlined in shelter plans created for the community or district, rather than reuniting at home before evacuating. Such disaster preparedness information should be disseminated as a matter of practice with the locals as well as the tourism department to share with visitors (Arlikatti et al., 2018).

Moreover, demographic correlations generally had nonsignificant correlations with behavioral response variables, which is consistent with the PADM's proposition that these variables only affect behavioral response indirectly, via information sources and psychological reactions—although the correlations of demographic characteristics with these two sets of variables were also weak. In addition, the Uttarakhand results are consistent with conclusions from two reviews of research on hurricane evacuation that labeled such correlations "weak and inconsistent" (Baker, 1991; Huang et al., 2016). This implies that evacuation planners in developed and developing countries alike can rely on the same principles in developing evacuation plans for all population segments within the risk area.

4.5 Study Limitations

All research studies have their limitations and this one is no exception. First, the sample over-represented males and scheduled caste/tribes. In other respects, it was generally representative of the geographical area. Second, people's relocation after the flood because of the destruction of their homes prevented selection of a sample that stratified households by their preimpact locations. Consequently, it is not possible to estimate the rates of different responses as a function of respondents' proximity to the floodway at the time of flood impact. Moreover, the sample necessarily over-represents survivors from Rudraprayag district and, thus, those who evacuated rather than remained in hazardous locations. The effect of this bias on the study's conclusions is difficult to determine because there are many reasons why people might have failed to evacuate—unfamiliarity with the terrain as religious tourists, misinterpretation of environmental cues, lack of forewarning of flood arrival, separated households waiting to reunite, and excessive time spent seeking warning confirmation or preparing to evacuate—to name a few.

Third, there is the possibility that systematic and random errors could affect respondents' self-reports. However, any systematic exaggeration of a response, such as artifactually increased levels of expected personal consequences, would add a constant that changes the mean for that variable but would typically leave any correlations with that variable unaffected. Differences in bias across respondents would add random error and, accordingly, attenuate the observed correlations below their true values (Nunnally & Bernstein, 1994). The magnitude of these effects would seem to be small, given other studies' findings of significant correlations between respondents' self-reports and observers' reports of those same behaviors (Lam & Cheng, 2002; Warriner et al, 1984) as well as reports from disaster studies (for a summary, see Lindell et al., 2016, p. 105-106).

Fourth, lack of clearly replicated scales for measuring affective response is another study limitation. Two previous studies have reported somewhat different factor structures even though all three studies used quite essentially the same set of items (Lindell et al., 2015; Wei & Lindell, 2017). Nonetheless, like this study, the other two have found that the affective response items do predict behavioral response (Lindell et al., 2015) and behavioral intentions (Wei & Lindell, 2017).

Fifth, the study is nonexperimental (e.g., households could obviously not be randomly assigned to floodway proximity or brochure/hazard meeting experience), so the omission of important unmeasured causal variables could have produced spurious correlations (Lindell, 2008). Moreover, the study's cross-sectional design precludes certainty about the temporal ordering of some of the variables, although it does seem reasonable to assume that demographic variables, hazard awareness program elements, location, and information sources did, in fact, temporally precede the psychological reactions and behavioral responses. One promising remedy for this problem would be to collect data on respondents' information sources, psychological reactions, and behavioral responses over time in actual events (Meyer et al., 2014; Ruin et al., 2014) and experiments (Wu et al., 2015a, 2015b).

Finally, the most important limitation of this study is, as has been the case with other evacuation studies, the modest levels of prediction of immediate evacuation (R^2 = .20), later evacuation (R^2 = .52), and evacuation delay (R^2 = .23). This indicates that much more research is needed to understand people's responses to imminent flood threat.

5.0 Conclusions

Comparison of the Uttarakhand data with the other flood studies identified in Appendix A indicates that the warning source was quite different but warning confirmation and other behavioral responses were quite similar. This suggests that the major difference in Uttarakhand was the lack of resilient hazard detection and warning dissemination infrastructure rather than distinct differences in the ways that people in rural India respond to the threat of imminent disaster. Moreover, the correlation and regression analyses provide important contributions to the development of evacuation models for flash flood risk areas that would be as useful as those for hurricanes and other events requiring large-scale evacuations (Lindell et al., in press).

The predominance of flood noise as the initial source of threat information for the Uttarakhand respondents suggests that this region would benefit from the establishment of a community based warning system. Such systems can be quite beneficial but they can also be rather problematic if not properly designed and supported by government (Gladfelter, 2018). In addition, some respondents' reliance on environmental cues such as torrential rain, animal behavior, and unusual changes in mountain slopes raises the issue of indigenous knowledge as a warning source (Balay-As et al., 2018). Although indigenous knowledge can, indeed, be a valid basis for hazard forecasts, it is also important to recognize that some people believe in hazard myths that have been scientifically disproven (Donner et al., 2012; Klockow et al., 2015; Whitney et al., 2004) and that there appear to be regional variations in the prevalence of beliefs in these hazard myths (Allan et al., 2017). Finally, there is a burgeoning literature on the design of warning messages that has identified the effects of different types of verbal, numeric, and graphic information on perceptions of strike probabilities, personal impacts, and intended behavioral responses (Bostrom et al., 2018; Casteel, 2018; Morss et al., 2018; Mu et al., 2018; Mu et al., 2018; Sutton & Woods, 2016). Of course, warning messages from official sources can only be effective if the hazards can be detected and warnings disseminated before hazard impact.

More broadly, the literature review reveals a scarcity of quantitative studies on household response to flash floods, coupled with a failure of recent studies to build upon the findings of previous research. It is possible that people's responses to flash floods has changed since some of the older studies were published 4-5 decades ago, so it is essential to conduct more studies that collect data such as that reported here. Studies that identify more effective mechanisms of hazard education and more closely examine the interaction of official warning systems with informal warning networks could complement situational analyses (e.g., Terti et al., 2017) in reducing the loss of life in floods.

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Table I. Summary results for sources of first warning and confirmation.

	Source of first notification/warning				Source of confirmation			
	Env. cues	Authorities	News media	Peers	Env. cues	Authorities	News media	Peers
Count	6	17	12	12	0	5	5	5
Minimum	13%	0%	0%	14%	0%	5%	24%	8%
Median	33%	21%	17%	38%	0%	20%	35%	27%
Maximum	50%	62%	52%	89%	0%	30%	60%	42%

Table II. Coding of variables.

Variable	Final Codes Used in Analysis
1 Age	Number of years
2 Female	Female = 1; Male = 0
3 Married	Married = 1; Other = 0
4 HHSize	Number of household members
5 Education	Graduate/professional degree = 7; Illiterate = 1
6 Income	Above Rs. 56,000 = 6; Below Rs. 4999 = 1
7 Homeown	Owner = 1; Renter = 0
8 Tenure	Number of years
9 PrevFldEvac	Previous flood evacuation = 1; No previous evacuation = 0
10 EmPrep	Number of emergency preparedness actions (0-9)
11 AtHome	At home = 1; Elsewhere = 0
12 HHTogeth	HH together = 1; Other = 0
13 Child<18	Number of children
14 VioNoise	Violent = 6; Unnoticeable = 1
15 FirstInfo	Social warning = 1; Social/environmental cues = 0
16 MessCont	Number of message elements (0-7)
17 EvacSourc	Number of sources recommending evacuation (0-4)
18 LandExp	Very certain = 5; Not certain = 1
19 LandArriv	Expected hours before arrival
20 ExpCons	Mean rating of 7 items
21 PosAff	Mean rating of 4 items
22 NegAff	Mean rating of 5 items
23 FirstResp	Evacuate = 1; Remain = 0
24 InfoSrch	Number of additional sources (0-5)
25 Confirm	Number of confirmation channels (0-11)
26 EvacPrep	Number of evacuation preparedness activities (0-5)
27 FinalResp	Evacuate = 1; Remain = 0
28 EvacDelay	Number of minutes

Table III. Characteristics of respondents (*N* = 316)

*Income**	*Percent*	*Marital status*	*Percent*
< Rs. 5,000	50.9	Married	74.7
5,000 – 10,000	23.1	Single	12.0
11,000-25,000	13.3	Widowed	13.0
26,000 – 40,000	6.3		
41,000 – 55,000	2.8	*Education*	
> 55,000	3.5	Illiterate	25.9
		Less than 9th grade	26.3
Female gender	41.5	Pass SSC	15.8
		Pass HSC	9.5
Age	*Md* = 40.0 (*SD* = 15.54)	Some college/voc. school	2.2
Number of household members		Bachelor degree	13.6
Less than 18	*M* = 2.04 (*SD* = 1.71)	Grad/prof degree	6.3
18-65	*M* = 4.03 (*SD* = 2.34)		
Greater than 65	*M* = 0.35 (*SD* = 0.64)	*Tenure (years)*	
		0-10	22.8
Caste		11-20	19.9
Upper	60.5	21-30	18.4
Backward	6.3	31-40	13.0
Scheduled	33.2	41-50	9.4
		> 50	16.5
Member with special needs	16.8		
		Hindu religion	99.4
Homeowner	88.0		

* 2013 exchange rate 1 USD = 60.725 Indian Rupees (Rs.)

Table IV. Means, standard deviations, and correlations among variables

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Age	43.06	15.5	1																			
2 Female	.41	.49	-.02	1																		
3 Married	.75	.44	.11	**-.26**	1																	
4 HHSize	6.43	3.31	**.17**	.06	-.05	1																
5 Education	8.87	6.88	**-.44**	**-.42**	.06	-.08	1															
6 Income	11930	1269	-.06	**-.15**	.04	**.17**	**.28**	1														
7 Homeown	.88	.33	.07	.03	-.04	**.15**	.03	.04	1													
8 Tenure	28.48	19.8	**.62**	-.10	-.03	**.22**	**-.26**	-.09	**.29**	1												
9 PrevEvac	.01	.08	-.01	.09	-.05	.00	.00	.04	-.09	-.01	1											
10 PreImPrep	1.69	2.09	-.08	-.09	.02	-.05	**.21**	.01	.00	-.03	.03	1										
11 AtHome	.70	.46	.08	**.42**	-.12	.03	**-.23**	-.12	**.18**	.10	.05	.08	1									
12 HHTogeth	.55	.50	.08	.06	.04	-.08	-.09	-.10	**.15**	.11	-.01	.06	**.38**	1								
13 Child<18	.56	.50	-.08	**.25**	.00	.06	-.09	**-.17**	.13	.00	.07	**.20**	**.39**	**.26**	1							
14 ViolNoise	5.50	1.31	.08	-.05	.06	.00	-.03	-.04	-.10	.01	.03	.05	.00	**.19**	.05	1						
15 FirstInfo	.29	.45	-.01	-.08	-.01	-.01	.06	.03	-.01	-.12	-.05	.06	-.11	-.10	-.09	**-.15**	1					
16 MessCont	1.17	.58	-.07	.11	.02	-.02	.07	**.24**	-.06	-.12	**.18**	.13	.04	-.08	.01	-.14	.08	1				
17 EvacSourc	.85	1.08	-.11	-.02	-.04	-.03	.10	.07	-.10	**-.16**	.01	**.27**	.02	-.01	.02	.01	**.25**	**.19**	1			
18 LandExp	1.80	.90	-.06	.04	-.04	-.02	.01	-.04	.02	.01	.06	**.15**	-.01	.03	**.15**	**.15**	-.12	.02	.14	1		
19 LandArriv	12.19	25.9	.06	-.08	.06	.02	.10	-.01	-.02	.10	-.04	-.01	-.03	.09	-.11	.10	-.04	.04	-.06	.10	1	
20 ExpCons	2.55	.51	-.10	-.02	.03	-.08	-.02	.00	-.04	-.06	.07	.05	-.06	.07	.12	**.21**	-.06	.00	.02	.13	.03	1
21 PosAffect	2.21	.66	-.02	**-.23**	.10	-.11	.12	-.04	-.03	-.02	.06	.08	-.12	.04	.13	.05	.14	.10	.01	.10	.13	.10
22 NegAffect	2.78	.47	.02	.11	.01	-.08	-.06	.06	.07	-.08	.04	.07	-.02	.14	.08	**.25**	-.09	.04	-.02	.11	.04	**.32**
23 FirstResp	.73	.44	-.02	-.12	.06	.03	-.03	-.04	-.12	-.03	.05	-.04	-.14	.14	.00	**.18**	-.06	.00	-.08	.04	**.15**	**.20**
24 InfoSrch	.47	.61	-.05	.01	.00	-.01	.03	-.05	.01	.02	.00	**.42**	.12	.05	**.18**	.03	.03	.13	**.37**	.07	-.13	.05
25 Confirm	1.37	.65	-.10	-.02	-.07	.01	.09	.03	.06	-.07	.02	**.25**	.03	.01	**.17**	-.04	-.01	**.32**	**.22**	**.16**	**-.17**	.08
26 EvacPrep	1.15	.85	-.06	-.10	.02	.07	**.18**	-.04	-.02	.05	-.01	**.45**	-.04	.02	.10	.04	.00	.09	**.23**	**.16**	-.03	.08
27 FinalResp	.80	.40	.04	-.07	.10	-.02	-.01	-.01	-.04	-.04	.04	.10	.02	**.30**	.13	**.25**	-.10	-.02	.12	**.15**	.10	**.23**
28 EvacDelay	.67	.47	-.02	-.14	.11	-.09	.01	-.08	-.02	-.01	-.13	**.18**	.06	.13	**.16**	.06	.13	-.02	.09	.00	**-.23**	.07

* all $r > .15$ are significant at $p < .01$ (2-tailed); $N = 152\text{-}316$

1. Age = respondent's age; 2. Female = respondent's gender; 3. Married = respondent's marital status; 4. HHSize = respondent's household size; 5. Education = respondent's number of years of formal education; 6. Income = respondent's annual income (in Indian Rupee); 7. Homeown = respondent's homeownership; 8. Tenure = respondent's length of residence in the community; 9. PrevEvac = previous evacuation experience; 10. EmPrep = respondent's emergency preparedness; 11. AtHome = respondent's physical context (at home); 12. HHTogeth = respondent's household context (household together); 13. Child<18 = respondents' social context (with child under 18); 14. VioNoise = perceived flood intensity; 15. FirstInfo = first information source (social source); 16. MessCont = number of message elements; 17. EvacSourc = numbers of sources recommending evacuation; 18. LandExp = landslide expectation; 19. LandArriv = expected landslide arrival time (in hours); 20. ExpCons = expected personal consequences; 21. PosAff = positive affect; 22. NegAff = negative affect; 23. FirstResp = respondent's immediate evacuation; 24. InfoSrch = number information sources searched; 25. Confirm = number of ways the threat was confirmed; 26. EvacPrep = numbers of pre-evacuation activities; 27. FinalResp = final threat response (evacuation); 28. EvacDelay = evacuation delay (in minutes)

Table IV (continued). Means, standard deviations, and correlations among variables

Variable	21	22	23	24	25	26	27
21 PosAffect	1						
22 NegAffect	.13	1					
23 FirstResp	**.21**	.14	1				
24 InfoSrch	.00	.08	-.13	1			
25 Confirm	-.03	.08	-.03	**.30**	1		
26 EvacPrep	.00	.11	.03	**.39**	**.36**	1	
27 FinalResp	.14	**.23**	**.49**	.12	.08	**.20**	1
28 EvacDelay	**.20**	-.01	-.06	**.26**	.13	**.19**	-

Table V. Cross-tabulation of first response vs. later evacuation (number of respondents in parentheses).

	Later evacuation								
First response	Stayed and continued activity	Stayed and awaited further info	Went to see water	Evacuated uphill	Evacuated downhill	Evacuated horizontally inland	Evacuated upstairs	Was elsewhere	Row total
Continued what I was doing	35.3(6)	11.8(2)	17.6(3)	29.4(5)	5.9(1)	0.0(0)	0.0(0)	0.0(0)	5.4(17)
Stopped but stayed	21.6(8)	21.6(8)	10.8(4)	43.2(16)	0.0(0)	0.0(0)	0.0(0)	2.7(1)	11.8(37)
Protected property	15.8(3)	0.0(0)	10.5(2)	63.2(12)	0.0(0)	5.3(1)	0.0(0)	5.3(1)	6.1(19)
Stopped and climbed	2.7(1)	0.0(0)	0.0(0)	91.9(34)	0.0(0)	0.0(0)	2.7(1)	2.7(1)	11.8(37)
Protected persons	10.3(3)	10.3(3)	6.9(2)	65.5(19)	0.0(0)	0.0(0)	6.9(2)	0.0(0)	9.2(29)
Immediately left building	1.5(2)	1.5(2)	0.8(1)	91.0(121)	2.3(3)	1.5(2)	0.8(1)	0.8(1)	42.4(133)
Pulled over to roadside	0.0(0)	5.0(1)	10.0(2)	75.0(15)	5.0(1)	5.0(1)	0.0(0)	0.0(0)	6.4(20)
Other	9.1(2)	27.3(6)	0.0(0)	50.0(11)	0.0(0)	0.0(0)	0.0(0)	13.6(3)	7.0(22)
Column total	8.0(25)	7.0(22)	4.5(14)	74.2(233)	1.6(5)	1.3(4)	1.3(4)	2.2(7)	(314)

χ^2_{49}= 148.03, p < .001, Cells contain row percent with cell count in parentheses

Table VI. Mediation analysis results

	First response (N=268)						Final response (N=307)						Final response (N=307)					
Variable	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)
ViolNoise	.18	.23	.11	4.94	.03	1.26	.25	.32	.09	12.31	.01	1.38	.25	.31	.09	11.19	.01	1.36
ExpCons	.20	.71	.27	6.93	.01	2.04	.23	.69	.27	6.61	.01	2.00						
NegAffect													.23	1.07	.28	14.55	.01	2.92
Constant		-2.00	.81	6.18	.01	.14		-2.16	.77	7.77	.01	.12		-3.29	.88	13.90	.01	.04
	χ^2_{2}= 15.33, p < .001;						χ^2_{2}= 23.45, p < .001;						χ^2_{12}= 32.05, p < .001;					
	-2 Log likelihood =290.40;						-2 Log likelihood =298.70;						-2 Log likelihood =290.10;					
	Cox & Snell R^2 = .06;						Cox & Snell R^2 = .07;						Cox & Snell R^2 = .10;					
	Nagelkerke R^2 = .08;						Nagelkerke R^2 = .11;						Nagelkerke R^2 = .15;					
	Correct classification = 74.3%						Correct classification = 78.5%						Correct classification = 78.2%					

Table VII. Expanded logistic regression analysis results

	First response (N=272)						Final response (N=268)						Evacuation Delay (N=218)					
Variable	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)	*r*	*b*	SE(*b*)	Wald	*p*	Exp(*b*)
PreImPrep	-.04	-.07	.09	.56	.45	.94	.10	-.03	.13	.06	.80	.97	.18	.06	.10	.42	.52	1.06
HHTogeth	.14	.73	.32	5.23	.02	2.07	.30	1.15	.45	6.55	.01	3.16	.13	.64	.34	3.53	.06	1.89
Child<18	.00	-.35	.33	1.13	.29	.70	.13	.81	.46	3.07	.08	2.24	.16	-.08	.35	.05	.83	.93
ViolNoise	.18	.23	.12	3.85	.05	1.26	.25	.12	.15	.57	.45	1.12	.06	.05	.15	.10	.75	1.05
MessCont	.00	.20	.30	.44	.51	1.22	-.02	-.38	.35	1.16	.28	.68	-.02	-.54	.30	3.29	.07	.58
ExpCons	.15	.72	.31	5.54	.02	2.05	.23	.01	.44	.00	.98	1.01	.07	.36	.34	1.13	.29	1.44
PosAffect	.21	.81	.24	11.42	.00	2.24	.14	.12	.31	.15	.70	1.12	.20	.80	.27	9.13	.01	2.23
NegAffect	.14	.19	.36	.27	.60	1.21	.23	.54	.48	1.23	.27	1.71	-.01	-.58	.51	1.33	.25	.56
FirstResp							.49	3.01	.48	39.98	.00	20.28	-.06	-.12	.47	.06	.81	.89
InfoSearch	-.13	-.75	.29	6.74	.01	.47	.12	.92	.49	3.54	.06	2.51	.26	.97	.33	8.68	.01	2.65
Confirm	-.03	.13	.26	.26	.61	1.14	.08	-.24	.43	.30	.59	.79	.13	.35	.29	1.49	.22	1.42
EvacPrep	.03	.18	.21	.77	.38	1.20	.26	.85	.36	5.69	.02	2.34	.19	.30	.24	1.59	.21	1.35
Constant		-4.62	1.28	12.97	.00	.01		-3.89	1.63	5.68	.02	.02		-1.65	1.78	.85	.36	.19
	χ^2_{11}= 40.66, p < .001;						χ^2_{12}= 103.40, p < .001;						χ^2_{12}= 39.52, p < .001;					
	-2 Log likelihood =275.76;						-2 Log likelihood =154.53;						-2 Log likelihood =242.40;					
	Cox & Snell R^2 = .14;						Cox & Snell R^2 = .32;						Cox & Snell R^2 = .17;					
	Nagelkerke R^2 = .20;						Nagelkerke R^2 = .52;						Nagelkerke R^2 = .23;					
	Correct classification = 77.2%						Correct classification = 86.9%						Correct classification = 74.3%					

Figure 1. Model of Behavioral Responses to Flash Flood Threat

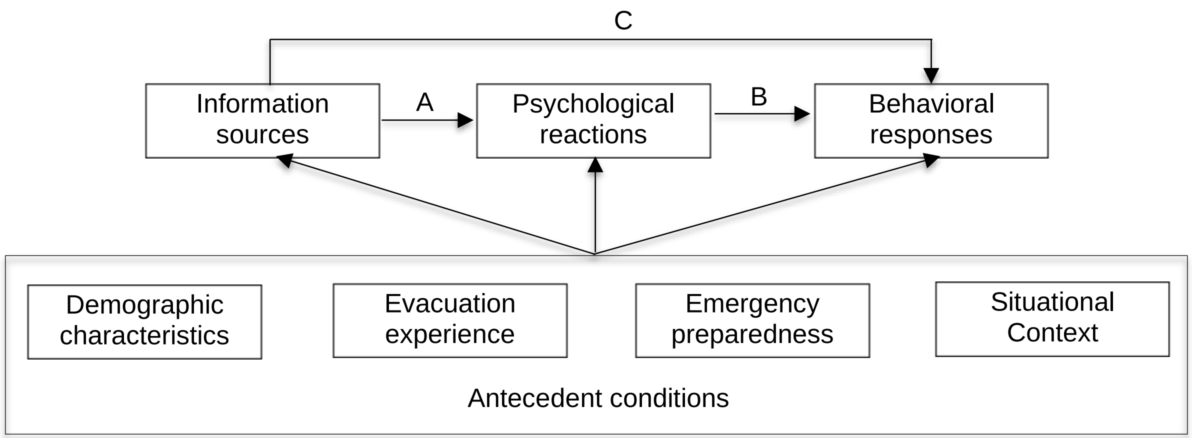
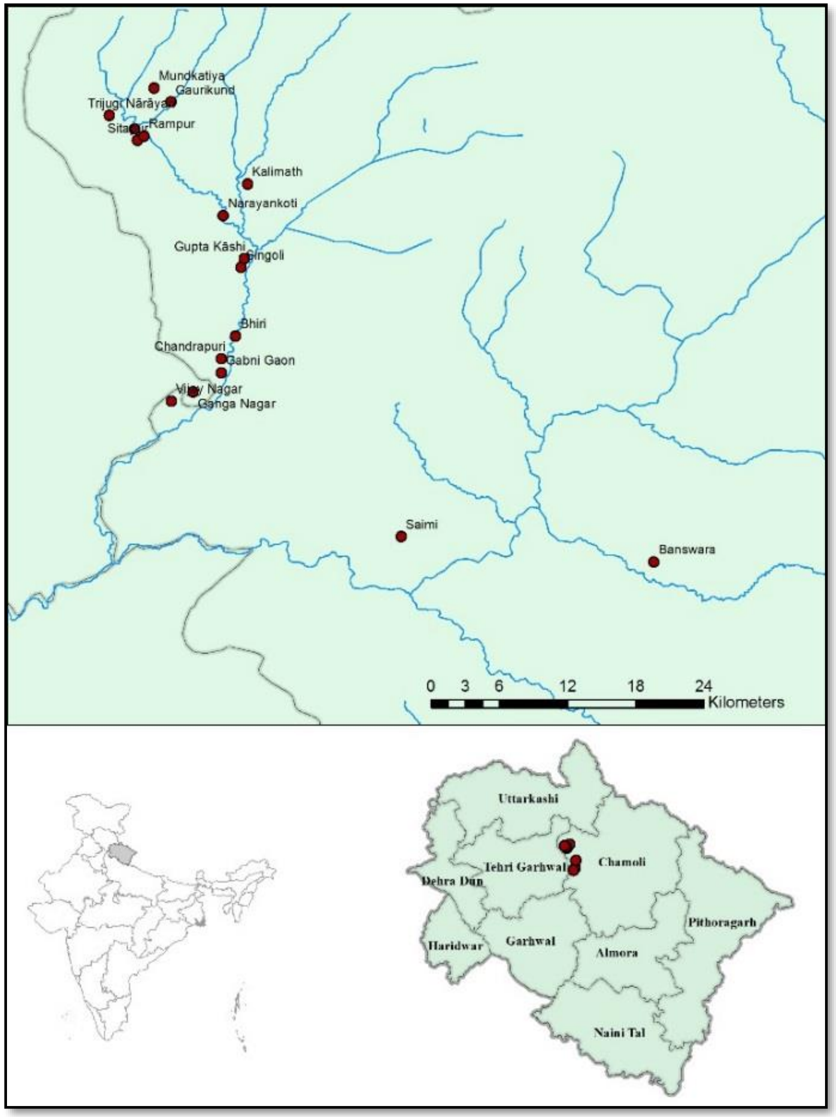


Figure 2. Study Area Map (Communities in Which the Survey Was Conducted are Identified on the Map).



Respondents by village/ communities

	Village name	District	Female	Male	Total
1	Banswara	Rudraprayag	1	4	5
2	Bhiri	Rudraprayag	6	3	9
3	Chandrapuri	Rudraprayag	14	38	52
4	Gabnigaon	Rudraprayag	24	10	34
5	Ganganagar	Rudraprayag	16	20	36
6	Gaurikund	Rudraprayag	0	13	13
7	Guptkashi	Rudraprayag	5	2	7
8	Kalimath	Rudraprayag	7	14	21
9	Mundkatiya	Rudraprayag	4	1	5
10	Naryankoti	Rudraprayag	5	10	15
11	Rampur	Rudraprayag	0	1	1
12	Saimi	Chamoli	11	4	15
13	Singoli	Rudraprayag	11	6	17
14	Sitapur	Rudraprayag	18	25	43
15	Sonprayag	Chamoli	2	25	27
16	Triyuginarayan	Rudraprayag	6	3	9
17	Vijaynagar	Rudraprayag	1	6	7
	Total number of respondents		131	185	316
			41.50% (F)	58.50% (M)	100% (Total)

Figure 3. Risk Perceptions and Affective Responses.

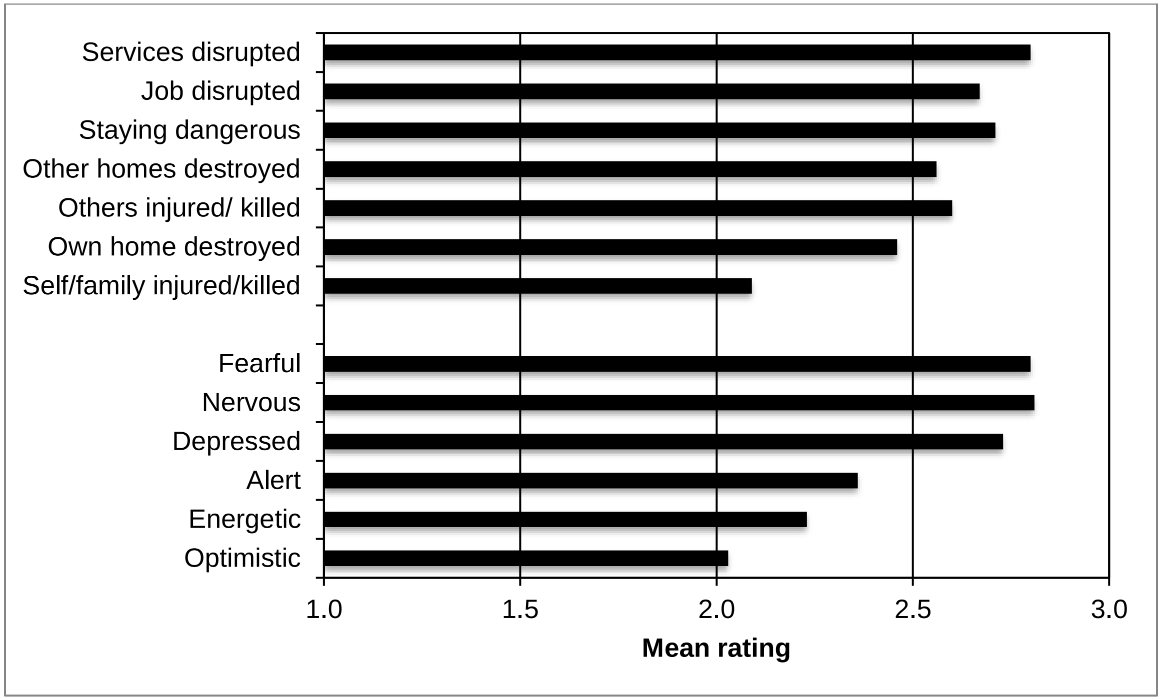
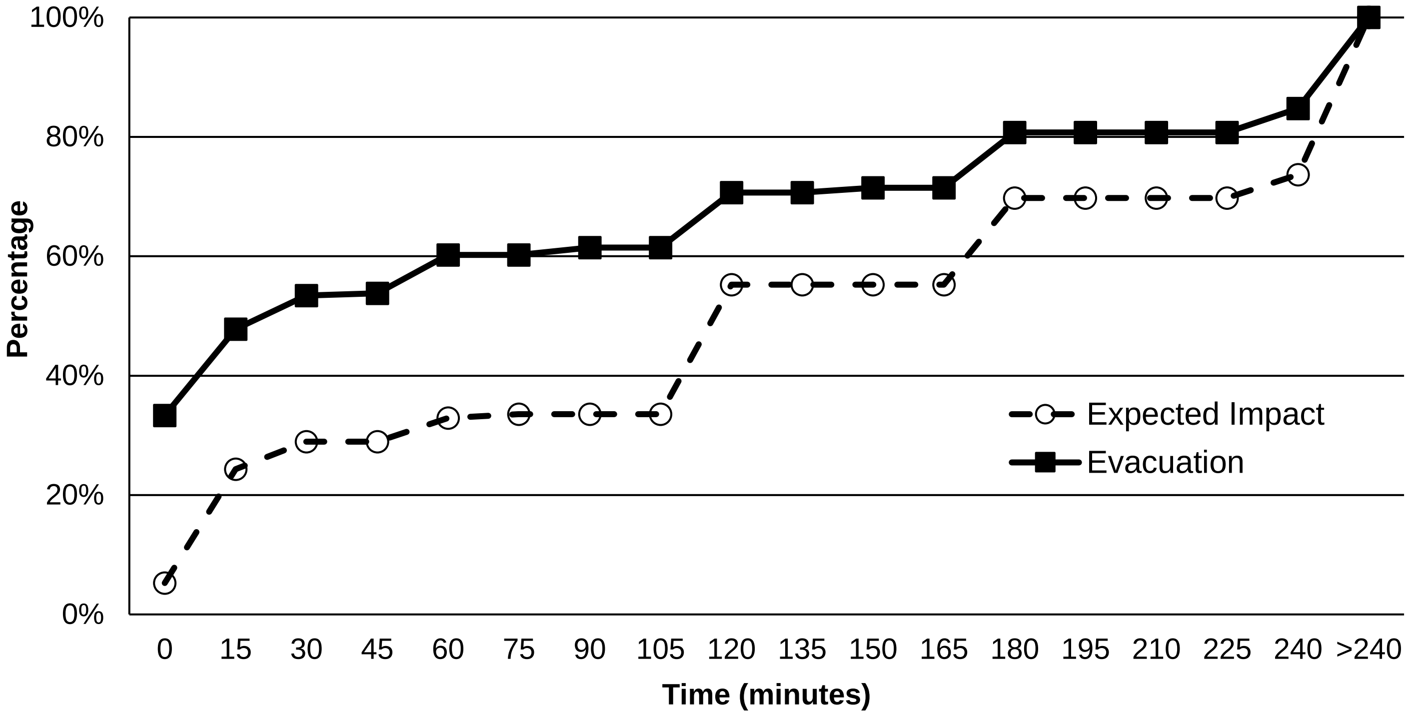


Figure 4. Cumulative percent of respondents reporting expected time of landslide and actual time of evacuation departure.



Appendix A. Sources of first warning and confirmation.

	Source of first warning				Source of confirmation			
	Env. cues	Authorities	News media	Peers	Env. cues	Authorities	News media	Peers
Previous flood studies								
Drabek (1969)								
- Colorado		19	52	29		9	50	41
Perry et al. (1981)								
- Fillmore		62	0	38				
- Snoqualmie		48	9	43				
- Sumner		11	0	89				
- Valley		42	20	38				
Perry & Greene (1983)[b]								
- Toutle/Silver Lake		48	11	41		29	33	19
- Woodland		21	20	59		20	60	8
Lindell & Perry (1992)								
- Abilene		30	48	22		5	35	42
Parker et al. (2007a)								
- Lower Thames	13	>23[c]	>13[c]	18				
Parker et al (2007b)								
- England/Wales		>30[c]	24	27		30	24	27
Werrity et al. (2009)								
- Scotland		42						
DeMarchi et al. (2007)								
- Bocenago	20	10						
- Romagnano	43	3						
- Roveré	40	0						
- Vermiglio	26	4						
Turner et al. (2014)								
- Punjab		2	>28[c]	>48[c]				
Nieland & Mushtaq (2016)								
- Toowoomba	50	16	14[d]	14[d]				
Other rapid onset hazard studies								
Rogers & Sorensen (1989)[e]								
- Pittsburgh hazmat	67	59	17	18				
Lindell & Perry (1992)								
- Mt. Vernon hazmat		37	19	44		16	30	32
- Denver hazmat		24	18	58		10	49	10
Lindell et al. (2015)								
- Samoa tsunami	46	14	15	11	9	12	16	24
Lindell et al. (2017)								
- Boston water contamination		13	41	42			87[e]	25[e]
Wei et al. (2017)								
- Christchurch tsunami							>48[c]	>73[c]

- Hitachi tsunami							>37[c]	>50[c]
Uttarakhand	67	1	0	29	70	3	3	30

[a] Source of first awareness [b] Source of first evacuation warning [c] Highest percentage among multiple alternatives in the same category; [d] 27% divided equally between news media and peers; [e] Percentages do not sum to 1.0 because multiple responses were allowed.