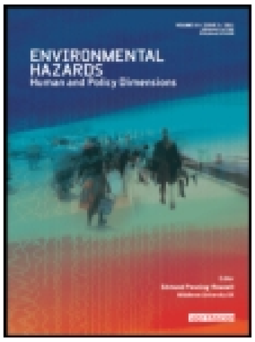

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Risk factors for driving into flooded roads

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Abstract

Motor vehicle-related deaths account for more than half of all flood fatalities in the United States, but to date, very little is known about the risk factors associated with why people drive into flooded roads. Using data from survey questionnaires administered in Denver, CO, and Austin, TX, this paper suggests that people who do not take warnings seriously are more likely to drive through flooded roads, as are people aged 18–35, and those that do not know that motor vehicles are involved in more than half of all flood fatalities. In Denver, people who have not experienced a flood previously and those who do not know they live in flood-prone areas are also more likely to drive into flooded roads.

Keywords: Floods; Vehicles; Risk behaviour; Logistic regression

1. Introduction

Floods are among the most common and deadly natural hazards (Berz et al., 2001; French and Holt, 1989), resulting in an average of 107 fatalities per year in the United States alone (NWS, 2006). Over half of these casualties involve people driving into flooded roads (Ashley and Ashley, 2007a), either by drowning in their vehicles or by escaping only to perish in the open water (French et al., 1983; Staes et al., 1994; CDC, 2000; NWS, 2006). The high rate of mortality associated with vehicles and floods was noted in the 1976 Big Thompson flood (Gruntfest, 1977; Gruntfest et al., 1978) and it remains true 30 years later (e.g., Staes et al., 1994; Zevin, 1994; Coates, 1999; Rappaport, 2000; Yale et al., 2003; Jonkman and Kelman, 2005).

In contrast with other hazards, there has not been a decline in the number of deaths associated with floods (Ashley and Ashley, 2007a). Therefore, in order to lower the mortality rate associated with motor vehicles and floods, we need to understand why people drive into flooded roads. Although there have not been any direct studies assessing the major risk factors associated with driving into water, there are numerous reports assessing why people react in certain ways during natural hazards. Each of the models emphasizes, to various degrees, the importance of the interaction between environmental information, social processes, and individual factors (e.g., Lindell and Perry, 1992; Tobin and Montz, 1997; Bandura, 1997; Sorensen, 2000; Grothmann and Reusswig, 2006). In general, these studies suggest that people react appropriately if they perceive the threat as being sufficiently hazardous to their health, they have previous experience with the hazardous situation, and there are few barriers to taking appropriate actions. However, Tobin and Montz (1997) and Kunreuther et al. (2002) are two of several studies that emphasize that humans do not function in a deterministic fashion with environmental information coming in on one side and appropriate behavior out the other.

Our objectives in this paper are to (a) determine risk factors associated with driving into flooded roads; and (b) use these risk factors to develop a predictive model for the likelihood that a person will drive into flooded water.

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We focus specifically on risk factors related to flood experience and knowledge, psychology and trauma (e.g., post-traumatic stress symptoms, coping self-efficacy), and demographics (e.g., age, gender). These results will begin to provide the National Weather Service, other warning personnel, and other interested parties with information on how people react when faced with driving and flooded roads. The results can then lead to targeted educational efforts or changes in the way warning information is communicated. The results also will add to the growing list of literature examining how people react in hazardous situations.

2. Data

2.1. The warning project survey

Denver, Colorado, and Austin, Texas, were selected as survey sites for this study. In Austin, floods are the leading cause of weather-related deaths (Austin City Connection, 2002). Although Denver has experienced fewer flood events than Austin, its location along the Colorado Front Range makes it a prime location for flash floods associated with severe thunderstorms (City and County of Denver, 2002). Approximately 6000 surveys were mailed to Denver and Austin flood-plain residents following the Dillman (2000) method for mail and internet questionnaires; the response rate was 14.8% from Denver, CO and 17.3% from Austin, TX. The questionnaires were first reviewed by a small select advisory committee composed of officials involved in floodplain management and weather warnings for Denver and Austin. The advisors were essential as a "local knowledge" base to enhance the likelihood that the most critical local aspects were incorporated in the survey design and to increase the chances that the study conclusions and recommendations will be applied in the field. Spanish language questionnaires were also developed to complement the English version. More details on the survey design and implementation are in the companion paper Hayden et al. (this issue).

2.2. Dependent variables

To assess whether respondents said that they would drive through flooded roads, they were presented with a "driving scenario" that placed them in a mid-size car immediately after a severe thunderstorm in their city (i.e., Denver or Austin). They were further told that approximately 18 in of water covered the road and that the vehicles ahead of them had stopped or were stopping. They then were asked to answer the following questions on a four-point Likert scale, ranging from "strongly agree" to "strongly disagree":

- If traffic started moving forward, I would attempt to cross the water.
- Regardless of the vehicle I'm driving, if water were covering most of the tires on the truck in front of me, I would attempt to drive through the water.
- If I were driving an SUV, truck, or 4-wheel drive instead of a car, I would attempt to drive through the water.

Results from Cronbach's α[1] indicated a strong association in the individual responses to the three questions ($\alpha = 0.78$), so a k-means clustering of the three driving scenario questions was employed to classify respondents into two groups ("I would drive through the water" and "I would not drive through the water"). Overall, 40% of Denver respondents ($n = 162$) were grouped into the "I would drive through flooded roads" category, compared with only 8% ($n = 41$) in Austin. In both cities, these respondents were coded as "1" and those that stated they would not drive through flooded roads were coded as "0".

2.3. Independent variables

The potential risk factors associated with driving through water were compiled based on single questions or composites of several questions. Because the questions asked on the Austin and Denver surveys were not identical, the constructs were based on similar, but not matching, questions from each survey. The constructs were all developed as dichotomous variables. If only one question was used for a construct, the "agree" and "strongly agree" responses were collapsed into "agree", and the "disagree" and "strongly disagree" responses were collapsed into "disagree", creating a dichotomous construct. Because the dependant coding was "1" for those that would drive through flooded roads and "0" for those that would not, the dichotomous constructs were also coded so that the responses that theoretically should increase the likelihood of driving into flooded roads were also coded as "1".

In comparison, if several questions were used for a construct, the first step was to measure the questions for reliability with Cronbach's α measurement. All questions had α values >0.70, so no additional steps were needed to develop a reliable base set. The data were then coded based on the mean or minimum value of the responses. As shown in Table 1, there are 11 dichotomous constructs in Denver and 10 in Austin. Some additional details on the constructs are listed in Table 2.

3. Methods

To assess whether a given construct is a risk factor associated with driving into flooded roads, the constructs were initially examined with contingency tables. Specifically, we examined whether the percentage of people who would drive into flooded roads varied based on a given

[1]Cronbach's α is a measure of the internal consistency or reliability of a set of questions. It is computed as the average correlation among questions. A threshold of 0.70 is often used to determine whether the given set of questions have internal reliability, with values greater than or equal to 0.70 considered to be indicative of a reliable set of questions.

Table 1
Characteristics and Cronbach's α scores for the constructs

Construct	Denver		Austin	
	Number of questions	Cronbach's α	Number of questions	Cronbach's α
Flood warning attitudes	1	1.000	1	1.000
Flood danger knowledge	1	1.000	1	1.000
Flood experience	1	1.000	1	1.000
Previous loss due to flood	2	0.745	2	0.827
Perceived threat susceptibility	1	1.000	1	1.000
Age	1	1.000	1	1.000
Gender	1	1.000	1	1.000
Safety efficacy	1	1.000	1	1.000
Post-traumatic coping self-efficacy	5	0.931	3	0.937
Post-traumatic stress symptoms	6	0.874	5	0.867
Environmental cues to action	4	0.726	0	N/A

For the Austin survey, none of the questions were relevant for the "Environmental cues to action" construct. All data are dichotomous variables.

construct, and we used a Pearson χ^2 to test whether the results were significant (i.e., p-values less than or equal to 0.10).

The constructs that had p-values less than or equal to 0.10 in the χ^2 tests were retained as a core set of potential predictors for the stepwise logistic model development. Conceptually, logistic regression applies maximum likelihood estimation after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent occurring or not). Therefore, logistic regression estimates the probability of a certain event occurring. This is particularly useful for our application because we can determine, for example, how age relates to the probability of a person driving through water. Logistic regression has recently seen increased use in environmental sciences (e.g., Monserud and Sterba, 1999; Shen et al., 2000; Yao et al., 2001), but to our knowledge, it has only been used sparingly in hazard studies (e.g., Wilmot and Mei, 2004; Grothmann and Reusswig, 2006).

Although logistic regression has several advantages over ordinary least-squares regression, especially for predicting binary outcomes, one drawback for logistic regression is that the interpretation of a logistic regression coefficient, β, is not as straightforward as that of a linear regression coefficient. However, the β coefficients can be converted into "odds ratios" that represents the ratio-change in the odds of the event of interest (i.e., driving into flooded water) for a change in the predictor category (e.g., a change in the age grouping).

The logistic regression models were fitted and validated using SPSS software. As noted previously, the convention

Table 2
Additional details on the constructs used as potential predictors for whether people would deliberately drive through flooded roads

Construct	Comments
Flood warning attitudes	Based on whether they take flash flood warnings seriously. Those that do not take warnings seriously were coded as 1
Flood danger knowledge	Based on whether respondents agreed with the statement that most deaths related to floods involved motor vehicles. Those answering "false" were coded as 1
Flood experience	Based on whether a person has experienced a flash flood in the lifetime. Those that have not were coded as 1
Previous loss due to flood	Based on whether respondents have had some form of economic or psychological loss due to a previous flood. Respondents without any loss were coded as 1
Perceived threat susceptibility	Based on whether respondents believe they live in an area where a flash flood may occur. Respondents answering "false" were coded as 1
Age	Based on which age category respondents answered. Stratified into 18–35 and 35+, with those in the 18–35 category coded as 1
Gender	Either male or female, with males coded as 1
Safety efficacy	Based on whether people believe they can keep themselves safe in the driving scenario. Those that believe they can keep themselves safe were coded as 1
Post-traumatic coping self-efficacy (PTCSE)	Refers to the respondents perceived ability to manage their most serious current stress or trauma. It was based on questions about a person's current perceived ability to cope with negative emotions, unwanted thoughts, and distressing dreams related to a traumatic event that threatened their life or someone close to them, where they felt intense fear or helplessness. Those with a low or moderate ability to cope where coded as 1
Post-traumatic stress symptoms (PTSS)	Based on a standard set of questions to diagnose whether respondents are suffering from symptoms of posttraumatic stress syndrome. This includes questions on how often a respondent experienced negative emotions, unwanted thoughts, and distressing dreams related to a traumatic event in the last month. Those with some PTSS were coded as 1
Environmental cues to action	Based on questions about environmental cues for flash flooding, such as heavy rain in the last few hours, rapidly rising water in nearby creeks, etc. Those with low awareness were coded as 1

for binomial logistic regression was followed and people who indicated they would drive into water were coded as 1 and people who indicated they would not drive into water were coded as 0. Final predictors were based on those that were retained by the stepwise regression (α to enter = 0.10; α to remove = 0.15), and the model was assessed by examining the Hosmer–Lemeshow goodness-of-fit statistic and the area under the relative operating curve (ROC), also known as the c-stat. The Hosmer–Lemeshow goodness-of-fit statistic tests the null hypothesis that the observed and model-predicted probabilities are identical (and thus p-values greater than 0.05 indicate a valid model), and the area under the ROC assesses the quality of the model across a variety of probability cut-points. As a general rule, Hosmer and Lemeshow (2000) indicate the models with c-stat values greater than 0.70 are acceptable, and those with c-stats values greater than 0.80 are excellent.

4. Results

4.1. Individual risk factors

To facilitate discussion of the risk factors, this section outlines the statistical results from Table 3 and presents some discussion for why they are or are not risk factors.

Flood warning attitudes. In both Denver and Austin, a key construct in determining whether a person is likely to state that they would drive through water is whether or not they take flash flood warnings seriously. In Denver, 38% of people who take flash flood warnings seriously say they would drive through flooded roads, compared with 66% who say they would drive through flooded roads if they do not take warnings seriously. In Austin the numbers are much lower, but the pattern remains the same; of the people who take flash flood warnings seriously, only 7% note that they would drive through flooded roads, whereas 30% of those who do not take warnings seriously state that they would drive through the flooded roads. These results suggest that public education campaigns should focus on ensuring that the public understands the seriousness of a warning. They also indicate that studies are needed to assess why some people take warnings seriously and others do not, particularly in relation to risky events like driving into flooded roads. To date, numerous papers have generated models that depict the interaction between environmental information, social processes, and individual factors to predict how people will respond to warnings (e.g., Lindell and Perry, 1992; Tobin and Montz, 1997; Sorensen, 2000). Each of the models emphasizes, to various degrees, the importance of physical cues, perceived risk, education, number of communication channels, and source credibility. However, it is also clear the importance of a particular factor will be based on the event; under certain conditions (e.g., a tornado is visibly approaching one's house) environmental factors will be the prime determinant of behavior. Under other conditions cognitive factors likely will serve as a more powerful influence on behavior.

Table 3
Chi-square results

Construct	Denver		Austin	
	χ^2	P-value	χ^2	P-value
Flood warning attitudes	10.302	0.001	15.738	0.000
Flood danger knowledge	4.790	0.029	5.869	0.015
Flood experience	4.57	0.033	0.271	0.603
Previous loss due to flood	1.260	0.262	1.291	0.256
Perceived threat susceptibility	4.758	0.029	0.257	0.612
Age	22.099	0.000	6.743	0.009
Gender	1.488	0.223	1.996	0.158
Safety efficacy	0.030	0.862	1.607	0.205
Post-traumatic coping self-efficacy	3.365	0.067	2.096	0.148
Post-traumatic stress symptoms	1.708	0.191	0.671	0.413
Environmental cues to action	1.574	0.210		

Flood warning attitudes, Flood danger knowledge, and age are valuable risk factors for driving into flood roads in both cities.

Flood danger knowledge. Of the respondents who correctly believe that most flash flood fatalities are related to vehicles, 31% (Denver) and 6% (Austin) state they would drive through flooded roads. In comparison, people who do not understand or do not know the dangers of flash floods and vehicles are significantly more likely to drive through flooded water (43% in Denver and 13% in Austin). There are some similarities between this construct and the one relating to flood warning attitudes; in both cases, people that recognize danger are more likely to take appropriate action. One reason that the percentages differ between this construct and the flood warning attitudes construct could be that flood danger knowledge does not force respondents to personalize their risk, which may be help people take preventative action (e.g., Slovic, 2001).

Flood experience. In both Denver and Austin, the percentage of people who state they would drive through water is higher for those who have not experienced a flood (45% vs. 33% in Denver; 9% vs. 8% in Austin), but the results are significant only in Denver. Supporting the Denver results, Grothmann and Reusswig (2006) suggest that previous flood experience is an important factor for taking precautionary action to prepare households against flood damage. On the other hand, supporting evidence for the Austin results are presented by Baker (1991) and Lindell et al. (2005), who showed little relationship between previous experiences with hurricanes and hurricane evacuations; theoretically, Kunreuther et al. (2002) noted that people often fail to learn from past experience, which could explain why this is not a significant risk factor in Austin.

Previous loss related to floods. This construct asked people whether they have suffered financial or emotional losses as a result of a previous flash flood. In Denver, 36% of individuals with no previous loss stated that they would drive through flooded roads, compared to 24% who said they would drive through flooded roads if they have some previous loss. In Austin, 11% of individuals with previous loss felt they would drive through flooded roads, compared with only 7% of those with no loss who noted that they would drive through flooded roads. None of these results are significant.

Perceived threat susceptibility. A similar construct has proven valuable in studies of people's reactions in other hazardous situations (e.g., Gladwin et al., 2001), but for our analyses there is only an effect on driving perceptions based on perceived threat susceptibility in Denver. People in Denver who think they do not live in an area where a flash flood may occur are more likely to state that they would drive through flooded roads (50% vs. 38%), whereas in Austin a relatively equal percentage of respondents felt that they would drive through flooded roads regardless of whether they think they live in an area where a flash flood may occur. To explain the Austin results, we hypothesize that simply knowing you live in a flood-prone area may not have an effect on your actions. As noted by the NRC (2006), people generally do not act on threat information until they perceive an imminent, personal risk. Yale et al. (2003) also suggested that many of the vehicular-related deaths during Hurricane Floyd involved people who were aware of flash flood warnings, but did not feel threatened by the possibility of encountering dangerous flood waters.

Age. The familiar adage, "With age comes wisdom" appears to apply to driving into flooded roads as well. In both cities, younger drivers (18–35) are much more likely to say that they would drive through flooded roads. Of the respondents aged 18 through 35, 63% in Denver and 14% in Austin state that they would drive through the flooded roads. In contrast, only 35% of Denver residents and 6% of Austin residents aged 36 or older note that they would drive through flooded roads. Although the age groupings in our study vary somewhat from those reported in other studies (e.g., Coates, 1999; Ashley and Ashley, 2007a), the results are generally consistent across all studies.

Gender. Previous research indicates that males participate in riskier driving behavior and NWS statistics from 1995 to 2004 bear out that nearly 2/3 of vehicular-related flood mortality victims are male (NWS, 2006; Ashley and Ashley, 2007a). Nonetheless, gender effects do not appear to be present in our data. In both cities, males are more likely than females to state that they would drive through flooded water (44% vs. 38% in Denver; 10% vs. 7% in Austin), but neither result is significant. Does this indicate no gender effect? Possibly, but we hypothesize that these results are more an artifact of the survey design than a reflection of reality. For instance, although real-world examples consistently point out gender effects, a meta-analysis of survey results on gender differences in risk-attitudes and behaviors performed by Byrnes et al. (1999) showed surprisingly little effect. Ronay and Kim (2006) conjecture that the discrepancy between experimental surveys and real-world data may be related to overlooking the importance of group dynamics. For example, self-administered studies, where the respondents are answering questions alone (as in this survey), typically show little or no gender effect, but experiments involving observed behaviors begin to show gender influences. In studies related to vehicles, McKenna et al. (1998) reported that the presence of a female passenger reduces the likelihood of an accident, and Chen et al. (2000) reported that the presence of a male passenger almost doubles the per capita death rate, regardless of the driver.

Safety efficacy. This question referred to the respondents perceived ability to keep themselves safe in the driving scenario. In both Denver and Austin, a roughly equal percentage of people said that they would drive into flooded roads, regardless of whether they feel they can keep themselves safe or not. Given that little research has examined how safety efficacy influences behavior in hazardous situations, further studies are needed to assess whether this is a realistic finding.

Posttraumatic coping self-efficacy (*PTCSE*). This construct measures an individual's perceived ability to cope with their most significant trauma; those with higher PTCSE indicate people who perceive themselves to be more capable of coping with their most significant trauma. In Denver, 53% of people with low-moderate PTCSE stated that they would drive through flooded roads, compared with 39% of people with high PTCSE who said that they would drive through flooded roads (p-value $= 0.07$). In Austin, 12% of people with low-moderate PTCSE noted that they would drive through flooded roads and 7% of people with high PTCSE said that they would drive through flooded roads, but this is not significant. The results suggest (for Denver at least) that people who perceive that they are less able to cope with a serious trauma in their lives may be more likely to drive through flooded roads. Based on research within other threatening situations, individuals with lower coping self-efficacy perceive potential threats as more unmanageable, thus causing heightened emotional and physical reactivity. This can constrain alternative options in decision making and ultimately impair functioning (Bandura, 1997).

Posttraumatic stress symptoms (*PTSS*). Loewenstein et al. (2001) suggested that posttraumatic stress symptoms (i.e., the emotional symptom cluster related to trauma exposure that includes intrusive thoughts, distressing dreams, and avoidance of trauma stimuli related to a traumatic event) are important in human decision making, especially under high stress environments. However, people suffering from some PTSS symptoms do not show a significant difference in their statements related to driving into flooded roads in either Denver or Austin. Most likely, the artificial reality of the survey combined with a random sample of a normal population did not adequately tap this aspect of hazard decision making.

Cues to action—environmental signs. This construct was only developed for Denver, and it was based on determining whether environmental cues, such as heavy rain in a few hours or rising water in a nearby creak, would prompt respondents to act differently in the driving scenario. Although it may intuitively seem that environmental signs should influence behavior, there was no significant difference in the rates of driving through flooded roads based on response to the environmental cues construct. We hypothesize that people believed that the environmental cues did not foreshadow a highly risky environment and they felt the probability of their being in a dangerous situation was negligible.

4.2. Logistic regression model results

The χ^2 results suggest that several dichotomous constructs may be valuable in predicting the likelihood of people driving through flooded roads (Table 3). For both Denver and Austin, flood-warning attitudes, age, and flood danger knowledge were significantly different between those who stated they would drive into flooded roads and those who stated they would not. Perceived threat susceptibility, PTCSE, and flood experience were also significantly different in Denver.

For Denver, four constructs were retained in the logistic regression model (Table 4). Overall, the Homer–Lemeshow test failed to reject the hypothesis that the model-estimated and observed probabilities are the same (p-value $= 0.48$) and the area under the ROC curve is 0.67 (slightly below the "acceptable" limit suggested by Hosmer and Lemeshow). Based on the odds ratio, age is the most important risk factor, followed by flood warning attitudes, flood danger knowledge, and flood experience. People 18 through 35 years of age are 3.39 times more likely to state that they drive through flooded roads than those over 35 years of age; people are 1.84 times more likely to say that they would drive into flooded roads if they do not take warnings seriously; people who do not know that most deaths related to floods involve vehicles are 1.75 times more likely to state that they would drive through flooded roads than those that do know; and people who have not experienced a flood are 1.42 times more likely to say that they would drive into flooded roads than those who have experienced a flood.

In Austin, only three predictors are retained in the logistic regression (Table 5). The Homer–Lemeshow test also fails to reject the hypothesis that the model-estimated and observed probabilities are the same (p-value $= 0.38$) and the area under the ROC curve is 0.65, slightly below Denver. Based on the odds ratio, the order of importance of the variables is similar, but not identical, to Denver, with the most important variable being whether people take warnings seriously, followed by age and flood knowledge. Austin residents that do not take flood warnings seriously are 4.34 times more likely to state that they would drive through flooded roads than those that take warnings seriously, while people aged 18–35 are 1.81 times more likely than aged greater than 35 to note that they would drive through flooded roads. Those with no appreciation for the dangers of driving through flooded roads are 1.80 times more likely to say that they would drive through flooded roads than those who understand the dangers of driving through flooded roads.

Table 4
Logistic regression model estimation results for Denver

Variable	β	Odds ratio	Standard error	Wald	Significance
Age	1.22	3.39	0.28	19.69	0.00
Flood warning attitudes	0.61	1.84	0.40	2.33	0.13
Flood danger knowledge	0.56	1.75	0.27	4.31	0.04
Flood experience	0.35	1.42	0.24	2.25	0.13

Table 5
Logistic regression model estimation results for Austin

Variable	β	Odds ratio	Standard error	Wald	Significance
Flood warning attitudes	1.47	4.34	0.51	8.31	0.00
Age	0.60	1.81	0.38	2.51	0.11
Flood danger knowledge	0.59	1.80	0.35	2.89	0.09

5. Discussion and conclusions

Motor vehicle-related deaths account for more than half of all flood fatalities in the United States, but to date, very little is known about why people tend to drive into flooded roads. Therefore, this research examined some of the major risk factors associated with driving into flooded water, and then used constructs to develop a binary logistic regression model. Data for this work were based on mail-in surveys conducted in Denver and Austin in 2005.

Overall, 40% of Denver respondents ($n = 162$) stated they would drive through flooded roads, compared with only 8% ($n = 41$) in Austin. We cannot definitively say why there is such a large difference between the two cities, but it is possible that differences in the relative occurrence of floods and flash floods play some role. For example, Ashley and Ashley (2007b) note large differences in historical flood events between Denver and Austin. We believe that the frequency of flood events likely plays some role in people's decision-making, and in future work we aim to test this by getting data from more cities. This should help us understand the relationship between the number of people who state they would drive into flooded roads and the occurrence of floods on a city by city basis.

Within each city, results indicated that several constructs are valuable for identifying risk factors associated with driving through flooded roads. Specifically, people who do not take warnings seriously state that they are more likely to drive through flooded roads, as are people aged 18–35, and those that do not know that motor vehicles are involved in more than half of all flood fatalities. In Denver, people who have not experienced a flood previously, those who do not know they live in flood-prone areas, and those with low-moderate PTCSE are also more likely to say that they would drive into flooded roads.

Based on the logistic regression models, important factors in determining whether respondents will drive into flooded roads include whether or not they take flash flood warnings seriously, their age, their knowledge of the danger of flash floods and vehicles, and in Denver, previous experience with floods.

These findings suggest that the National Weather Service and other public warning agencies need to focus education efforts on ensuring that the public (especially younger sectors) understand warnings, the importance of paying close attention to warnings, and the dangers inherent in driving through flooded roads. This could involve identifying receptive moments, such as public service announcements during popular television programs, but it also indicates that the message needs to be tailored to a younger audience. For example, the NWS instituted the "Turn Around Don't Drown" campaign in 2003 (http://www.srh.noaa.gov/tadd/), and early results suggest the message may be helping. However, research on the efficacy of this campaign for high-risk sub-populations should be undertaken. Future research also needs to examine the dissemination of weather warnings to determine if improvements in the medium (e.g., TV versus internet) or mode (e.g., icons versus verbal) of messaging can make a difference in how people react (as noted by the NRC, 2006; see also Hayden et al., this issue). Follow-on studies with clinical trials or more realistic driving simulations are needed to confirm the results from this study and to assess whether psychological trauma and gender affect driving behavior in a hazardous flooding environment.

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