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DRIVING UNDER THE INFLUENCE OF WEATHER: PERCEPTIONS OF FLASH FLOODS AND VEHICLE SAFETY

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1. INTRODUCTION

Floods are among the most common and deadly natural hazards (Berz et al., 2001), 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 water, 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 and it remains true thirty years later (e.g., Staes et al., 1994; Rappaport et al., 2000; Yale et al., 2003; Jonkman and Kelman, 2005).

Although these previous reports have clearly established that people deliberately drive through flooded roads, little research has centered on why people drive into flooded water. The latter information is crucial for improving future education efforts, and the objective of this paper is therefore to determine risk factors associated with driving through flooded roads.

2. DATA

2.1 *Dependent Data*

Data for this paper were based on approximately 1000 self-administered mail-in surveys from Denver, CO and Austin, TX. To assess whether respondents would deliberately drive into flooded roads, they were presented with a “driving scenario” that placed them in a mid-size car after a severe thunderstorm. They were further told that approximately 18 inches of water covered the road and that the vehicles ahead of them had stopped or were stopping. They then were tasked with answering 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 alpha indicate a strong association in the individual responses to the three questions (α = 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 = 214) 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”.

2.2 *Independent Data*

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 developed as dichotomous variables,

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with the “agree” and “strongly agree” responses collapsed into “agree”, and the “disagree” and “strongly disagree” responses collapsed into “disagree”. 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 through flooded roads were also coded as “1”. As shown in Table 1, there are six dichotomous constructs. A full discussion on how they relate to driving through flooded roads is left until the results section.

Table 1. 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.
Flood knowledge	Based on whether respondents agreed with the statement that most deaths related to floods involved motor vehicles.
Age	Based on which age category respondents answered. Stratified into 18–35 and 35+.
Gender	Either male or female
Perceived threat susceptibility	Based on whether respondents believe they live in an area where a flash flood may occur.
Flood experience	Based on whether a person has experienced a flash flood in the lifetime.

3. METHODS

To assess whether a given construct is a risk factor associated with driving through flooded roads, the constructs were initially examined to see if there were significant differences between the two driving scenario clusters. Specifically, a Pearson chi-square test was used for this analysis. The chi-square test is useful for 2x2 contingency tables (as is the case here) and for a given construct it tests the probability that the observed differences between the two driving clusters could be replicated by chance. For this paper, none of the observed cell counts were less than five, so Yates' correction, which is an arbitrary, conservative adjustment to the chi-square statistic when at least one cell has a count less than 5, is not employed. More details on the Pearson chi-square are available in introductory level social science statistics textbooks, such as Sirkin (2006).

4. RESULTS

To facilitate discussion of the risk factors, this section outlines the statistical results from Table 2 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 drive through water is whether or not they take flash flood warnings seriously. In Denver, 39% of people who take flash flood warnings seriously would drive through flooded roads, compared with 62% who 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% would drive through flooded roads, whereas 30% of those who do not take warnings seriously would drive through the flooded roads. These results suggest that public education campaigns should focus on ensuring 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 high-risk, low-probability events like driving through flooded roads. To date, numerous papers have generated models that depict the interaction between environmental information, sociological processes, and individual factors to predict how people will respond to warnings (e.g., Lindell and Perry, 1992; Tobin and Montz, 1997). 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., 150 mph winds from a tornado tearing off parts of one’s house as the black swirling funnel can be seen from the window) environmental factors will be the prime determinant of behavior. Under other conditions cognitive factors likely will serve as a more powerful influence on behavior.

Flash flood knowledge: Of the respondents who correctly believe that most flash flood fatalities are related to vehicles, 34% (Denver) and 6% (Austin) still 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 far more likely to drive through flooded water (44% 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. However, whereas flood warning attitudes implies a specific, imminent risk, flash flood knowledge only informs about whether respondents have a general, conceptual understanding of the dangers of driving through flooded roads. In other words, this construct does not force respondents to personalize their risk, which may be a key factor in taking preventative action (e.g., Slovic, 2001).

Age: The familiar adage, “With age comes wisdom” appears to apply to driving through flooded water as well. In both cities, younger drivers (18–35) are much more likely to drive through flooded roads. Of the respondents aged 18 through 35, 56% in Denver and 14% in Austin would drive through the flooded roads. In contrast, only 35% of Denver residents and 6% of Austin residents aged 36 or older would driver 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, 2006), the results are generally consistent.

Gender: Previous research indicates that males generally participate in riskier driving behavior, and NWS statistics from 1995–2004 bear out that nearly 2/3 of vehicular-related flood mortality victims are male (NWS, 2006). Nonetheless, gender effects appear to be only marginally present in the data. In Denver, males are more likely to drive through flooded water (47% vs. 37%) but there is no evidence of a gender effect in Austin (10% vs. 7%). It is possible that the Austin results are based on something real, such as greater experience with floods and flood warnings, but it is more likely to be an artifact of the survey design. For instance, in situations where people have little experience in dealing with hazardous situations (Denver has far fewer flash floods than Austin), people tend to follow social norms (Kahn and Baron, 1995; Sunstein, 1996), and therefore it is conceivable that the gender effect should be enhanced in Denver. Nonetheless, although real-world examples consistently point out a gender effect, a meta-analysis of gender differences in risk-attitudes and behaviors for surveys 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 particular, 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. Additional research is therefore needed to better understand what role gender plays in deliberately driving into flooded roads.

Perceived threat susceptibility: Although this construct has proven valuable in studies of people's reactions in other hazardous situations (e.g., Gladwin et al., 2001), for our analyses there is no effect on driving response based on perceived threat susceptibility. In both Denver and Austin, a relatively equal percentage of respondents would drive through flooded roads regardless of whether they think they live in an area where a flash flood may occur. We theorize 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.

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 (44% vs. 37% in Denver; 9% vs. 8% in Austin), but the results are not significant. Similar findings between previous experiences and hurricane evacuations were noted by Baker (1991) and Lindell et al. (2005), so there is evidence that experience is not a risk factor in other hazardous situations either. Theoretically, Kunreuther et al. (2002) note that in high-risk low-probability events (such as driving through flooded roads), people often fail to learn from past experience, which would explain why this is not a significant risk factor. However, Grothmann and Reusswig (2006) suggest that previous flood experience is an important factor for taking precautionary action to prepare households against flood damage. Therefore, it is possible that previous experience plays a more important role in long-range precautionary planning, but may not influence actual safety behaviors during an event.

Table 2. Pearson chi-square statistics.

Construct	Denver	Austin
Flood Warning Attitudes	11.509**	15.738**
Flood knowledge	5.003**	5.869**
Age	19.095**	6.734**
Gender	4.563**	1.996
Perceived threat susceptibility	2.000	0.257
Flood experience	2.076	0.271

* = significant at 0.10
** = significant at 0.05

4. CONCLUSIONS

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

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 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, males were also more likely to drive through flooded roads.

In conclusion, vehicle-related flood deaths have remained a significant percentage of flood mortality for 30 years and with the prospect of expanding populations and increased flood risk due to global warming (Milly et al., 2002; Palmer and Räisänen, 2002), vehicular deaths during floods are likely to continue to be a major problem in the future. Results from this work suggest several risk factors that should be addressed through targeted campaigns, which may save future lives and property.

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