

A Review of People's Behavior in and around Floodwater

J. S. BECKER, H. L. TAYLOR, B. J. DOODY,* AND K. C. WRIGHT**

Joint Centre for Disaster Research, GNS Science and Massey University, Wellington, New Zealand

E. GRUNTFEST

University of Colorado, Colorado Springs, Colorado

D. WEBBER

New South Wales State Emergency Service, Wollongong, Australia

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ABSTRACT

A study was undertaken to review international literature pertaining to people's behavior in and around floodwater. The review focused on people's voluntary entry of floodwater. From the literature, five predominant reasons for entering floodwater were identified, including undertaking a recreational activity; attempting to reach a destination; retrieving property, livestock, or pets; undertaking employment duties; and rescuing or assisting with evacuation. Two primary influences on entering floodwater were found, namely risk perception (i.e., being unaware of or underestimating the risk from flooding) and social influences (i.e., being influenced by others). Demographics and environmental and temporal factors also played a part in decision-making about whether to enter floodwater or not. Emergency managers should take account of such factors when devising future public education strategies. Further research, including comparisons with current theoretical models, could help identify additional influences on decision-making for floodwater entry.

1. Introduction

Flooding is one of the leading causes of deaths associated with natural disaster events (Ashley and Ashley 2008; Coates and Haynes 2008; Jonkman 2005; Jonkman and Kelman 2005). According to the World Disasters Report 2011, 60% of the 304 million people affected by natural disasters in 2010 were impacted by floods (IFRC 2011). In that year, 8408 people were reported to have been killed by flooding; there had been an additional 47 892 individuals killed in the nine years prior (2001–09) (IFRC 2011). Most people who die in floods die from drowning (Coates 1999; Coates and Haynes 2008; French

et al. 1983; Jonkman and Kelman 2005), with around 70%–90% of people drowning in floodwaters (French et al. 1983; Coates and Haynes 2008; Jonkman and Kelman 2005). Other common causes of flood deaths are physical trauma, heart attack, fire, electrocution, overexertion, and shock (Coates and Haynes 2008; Jonkman and Kelman 2005).

A significant number of flood-related deaths have been linked to avoidable behavior, such as voluntarily entering floodwaters (Ashley and Ashley 2008; Coates and Haynes 2008; Drobot et al. 2007; Jonkman and Kelman 2005; WHO 2002). Consequently, a challenge for emergency managers is how to encourage people to stay out of harm's way and keep out of flooded areas. To inform emergency management practice, a better understanding is needed about why people undertake such behaviors. With a better understanding of why people voluntarily enter floodwater, more effective public education and warning strategies can be designed to empower people to make better choices.

To help inform understanding about people's behaviors in and around floodwater, a study was initiated to

* Current affiliation: Durham University, Durham, United Kingdom.

** Current affiliation: Ministry of Civil Defence & Emergency Management, New Zealand.

Corresponding author address: Julia Becker, GNS Science, P.O. Box 30368, Lower Hutt 5040, New Zealand.
E-mail: j.becker@gns.cri.nz

review all relevant international literature on the topic. The review focused on people's voluntary actions in and around floodwater, and possible reasons for why they may have taken the actions they did. A number of papers have captured data on people's behaviors in and around floodwater in different flood contexts, but none have sought to thematically summarize the main influences on why people choose to enter water. This paper attempts to do this.

This paper will first outline the basic methodological approach taken for this study, then report on the findings related to people's behavior in and around floodwater, and finally discuss implications for the findings with regard to public education and warning strategies.

2. Methodology

The methodology for the project was primarily a literature review of people's voluntary behaviors in and around floodwater. This included investigating actions such as driving, walking, or playing in floodwater, and attempting to find reasons for why people undertake such actions.

To undertake the literature review, information was collected from a variety of English language sources including peer-reviewed journal articles, book chapters, reports, theses, unpublished material (e.g., websites, information from agencies), and discussion with experts. The material was sourced from a variety of countries and regions including Australia, the United States, New Zealand, Europe, and Asia. The review attempted to be as comprehensive as possible, but most of the relevant and accessible publications found were from Australia, the United States, and Europe. Following the collation of relevant material, an analysis of the material was undertaken to determine the main themes that arose related to people's behavior in and around floodwater.

Both "slow" riverine floods (including those that interacted with river mouths) and flash flooding were considered in the review. The authors acknowledge that riverine and flash flooding are different types of flood, which may prompt different types of voluntary action, and attempt to note that in the text where possible. However, we have also tried to generalize some of the main themes that are relevant to both riverine and flash flooding.

3. Results

a. Voluntary actions

In the first instance the review investigated the types of voluntary actions that people undertake when they

enter floodwater. Five main activities were identified including undertaking a recreational activity; attempting to reach a destination; retrieving property, livestock, or pets; undertaking employment duties; and rescuing or assisting with evacuation.

1) UNDERTAKING A RECREATIONAL ACTIVITY

Those who enter floodwater for recreational purposes are likely to underestimate the dangers. Several studies have noted that individuals may enter floodwater to undertake a recreational activity (Coates and Haynes 2008; FitzGerald et al. 2010; Franklin et al. 2014; Jonkman and Kelman 2005; League 2009; Zhong et al. 2013). Over the period of 1980 to 2008, 16% of Australian flood victims were swimming, playing, paddling, or bathing in the floodwater; 5% were boating, acting on a wager, or joyriding; and 3.6% were on a boat or makeshift boat at the time of their death (Coates and Haynes 2008). Australian figures for the more recent period of 1997–2008 show 27% of flood fatalities were swimming or surfing and 4% were in a boat in floodwater (FitzGerald et al. 2010). In the 2010/11 Queensland, Australia, flood event, seven people (21%) drowned while undertaking activities in flooded waterways (e.g., swimming, kayaking, and walking; Zhong et al. 2013). In 1983, 2% of flood deaths in the United States were linked to rafting and sailing (French et al. 1983). Recreational boating in floodwater has accounted for 3.6% of flood fatalities in the United States and Europe (Jonkman and Kelman 2005). Recreational activities and other activities such as sightseeing account for 47% of flash flood near misses and injuries (Coates and Haynes 2008).

Sightseeing or the idea of "flood tourism" has been documented in several studies. Jonkman and Kelman (2005) report significant crowds gathering on riverbanks and bridges during European floods as well as recreational boating on flooded waterways. Campers in southern France died in their attempt to get a closer view of a flood (Ruin et al. 2009). A study by League (2009) investigated people who posted videos on YouTube of themselves driving through flooded roads. Most had entered the waters for fun or to film the flood, thus voluntarily entering the floodwater.

The trend to enter floodwater voluntarily for recreational purposes is increasing. Fatalities resulting from recreational activities in and around floods have increased in Australia from 5% of fatalities in 1950–1979 to almost 25% in 1980–2008 (Coates and Haynes 2008).

2) ATTEMPTING TO REACH A DESTINATION

A predominant reason why people enter floodwater is to try to reach a particular destination (Becker et al.

2010; Coates 1999; Coates and Haynes 2008; Franklin et al. 2014; League 2009; Ruin et al. 2009). Generally these efforts are made in order to maintain daily routines such as traveling to and from work or dropping off and picking up children from school. Nine percent of all flood-related deaths in the United States are reported to be a result of people trying to reach a destination (Ashley and Ashley 2008). In Australia, this accounts for around a quarter of flood fatalities (Coates and Haynes 2008; Zhong et al. 2013) and 11% of near misses and injuries (Coates and Haynes 2008). Coates and Haynes note an increase in deaths of this kind in Australia, from 15% in the years 1950–79 to 26% for 1980–2008.

Becker et al. (2010) undertook a series of focus groups in Australia that provided anecdotal evidence of the rationales people use for entering floodwater. One participant in their study reported leaving home on foot to obtain baking supplies because there was nothing to do. The woman said she felt safe to enter the floodwater because the water was not rushing and only at midcalf height. During the time she was out, the water rose and continued to do so rapidly on her return trip. Although the water reached waist deep, she continued wading through it in order to return home.

3) RETRIEVING PROPERTY, LIVESTOCK, OR PETS

It is common for people to enter floodwater in order to rescue or retrieve property, livestock, or pets, whether it is theirs or others (Becker et al. 2010; Coates 1999; Coates and Haynes 2008; Ruin et al. 2009; Taylor 2011; Diakakis and Deligiannakis 2013). In Australia, Coates and Haynes (2008) determined that 11% of all flood fatalities between 1950 and 2008 were because of this reason. They noted a decline in this number from 25% in 1950–79 period to 3.5% in 1980–2008 and suggested this may be because less importance is being placed on belongings and there is a greater understanding of the dangers of flash flooding. Participants of Becker et al.'s (2010) study reported walking through the waters in order to check on their property or save items. Before entering the waters, they would gauge whether it was safe to do so, by making personal assessments of the depth and speed of the water.

4) UNDERTAKING EMPLOYMENT DUTIES

Some individuals encountered floodwater directly or indirectly in the context of their jobs. A significant number of people have continued to maintain their normal activities, including commuting to work (Coates and Haynes 2008; League 2009; Ruin et al. 2009). Other people such as emergency services and utilities maintenance workers are required to enter the floodwater. In Australia, 12% of flood fatalities

between 1788 and 1996 were work related (Coates 1999). Some vulnerable groups identified were miners (2.8%), rescue personnel (1.4%), and mail delivery personnel (0.9%) (Coates 1999).

5) RESCUING, OR ASSISTING WITH EVACUATION

Finally, people enter floodwater as rescuers or to assist with evacuations. Of 97 fatalities between 1950 and 2008 in Australia, 4.1% were professional rescuers, firemen, or police, and 2.1% volunteers attempting to rescue others (Coates and Haynes 2008). French et al.'s (1983) study reported rescuers being 3% of fatalities in the United States. The more recent study of the United States and Europe by Jonkman and Kelman (2005) attributed 1.2% of fatalities to rescuers. A flash flood in Nimes, France, revealed higher percentages—two of the nine people who drowned in the flood were rescuers (Duclos et al. 1991). In terms of injuries and near misses, Coates and Haynes' (2008) study found that 5.8% of individuals involved in these were professional rescuers and 3.5% were volunteer rescuers.

Interestingly, the percentage of flood fatalities that occur during the evacuation process relative to the overall number of fatalities is low (Ashley and Ashley 2008; Coates 1999; Coates and Haynes 2008; French et al. 1983). Between 1950 and 2008, only 6.1% of flood fatalities in Australia occurred during the evacuation process (Coates and Haynes 2008). Since 1980, these types of fatalities have made up only 1.8% of Australian flood fatalities (Coates and Haynes 2008). In the United States, only 2% of deaths (excluding those involving cars) were connected to evacuation (French et al. 1983). Of the fatalities that have resulted from walking through floodwater, only 16% of these are suggested to be a result of attempts to rescue or evacuate others (Ashley and Ashley 2008). These figures support the conclusion that a significant number of fatalities are associated with avoidable risk-taking behavior (Ashley and Ashley 2008; Coates and Haynes 2008; Drobot et al. 2007; Jonkman and Kelman 2005; WHO 2002).

b. Influences on voluntary actions

Second, the review looked deeper into the reasons why people undertook actions to enter floodwater. Two primary influences on entering floodwater were found. These included risk perception (i.e., being unaware of or underestimating the risk from flooding) and social influences (i.e., being influenced by others).

1) RISK PERCEPTION (UNAWARE OR UNDERESTIMATING RISK)

When people are confronted with floodwater, it appears that they are often unaware of or underestimate

the risk associated with flooding, and consequently do not act accordingly (Diakakis and Deligiannakis 2013; Drobot et al. 2007; Franklin et al. 2014; Jonkman and Kelman 2005; Ruin et al. 2007, 2009). Sedwick (2008) ascribes the “willingness to enter floodwater (or get in the way of a flash flood) to an underestimation of the risk, underestimation of the speed and power of moving water, and an overestimation of ability to survive.” This is particularly evident in the case of driving into floodwater. Franklin et al. (2014) directly asked participants in their survey about what they thought the main reason was that people drive into floodwater and 61.5% of people said “awareness.” Individuals stated that they were not aware or knowledgeable about the dangers or risks posed by flooding.

Ruin et al. (2007) found that drivers typically underestimate risks rather than overestimate them. The Clark County Regional Flood Control District (CCRFD) in Texas found that over 50% of survey respondents who enter floodwater in vehicles during flash floods do so because they do not think it is unsafe to do so (Clark County Regional Flood Control District 2009). The percentage of people choosing to drive into floodwater decreased, however, from 43% to 30% of Texan respondents between 2000 and 2009, even though the percentage of those underestimating the risk has remained relatively constant (Clark County Regional Flood Control District 2009).

Another study of Texan flood fatalities by Maples and Tiefenbacher (2009) concludes that familiarity with roads may play a role in drivers attempting to drive through rushing floodwater. Thirty-eight of the 140 fatal incidents analyzed in this study were in close proximity to people’s homes or on their route to or from work. Of these drivers, it is believed that 71% (27 of 38 incidents) had roadway familiarity (Maples and Tiefenbacher 2009). The notion that environmental familiarity causes individuals to underestimate risks has been found in other studies (Petrucci and Pasqua 2012). Those living in flood-prone areas are aware of the general risks of flooding, but they often underestimate the dangers posed and, more significantly, they are unaware or believe their own property and lives are not at risk (Brilly and Polic 2005; Burningham et al. 2008; Clark County Regional Flood Control District 2009; Krasovskaia et al. 2007).

Linked to underestimation of risk is an optimism (Weinstein 1980) that no harm will come to people if they enter floodwater. Examples of this optimistic bias can be found in previous research. Shabanikiya et al. (2014) found that some individuals overestimate their ability to deal with floodwater. In their study they found that those who believed they could swim well (with moderate to advanced swim levels) were more likely to

enter floodwater. In a survey by Franklin et al. (2014) 30.8% of respondents stated that they had driven into floodwater because they believed they were “invincible,” suggesting an overconfidence that nothing would happen to them. Those who had entered floodwater previously and experienced no negative impacts also considered themselves more likely to enter in future (Becker et al. 2010), as per normalization bias (Mileti and O’Brien 1992).

2) SOCIAL INFLUENCES

The influence of others has been found to be cause for people to enter floodwater, particularly for driving. A number of individuals in Australia (Becker et al. 2010; Franklin et al. 2014) and the United States (League 2009) reported that they would often follow others or drive into floodwater if they had seen the car in front of them cross successfully. In fact, more than 50% of respondents in League’s (2009) study indicated they were influenced to drive through the water because the previous car had driven across and made it through to the other side. The influence of others in prompting people to enter floodwater is also evident in the prior discussion about people recreating in floodwater [section 3a(1)], and in people’s perceived responsibility for employment duties during flooding [section 3a(4)].

c. Demographics

The literature review revealed that people of certain demographic profiles are more likely to undertake inappropriate actions around floodwater. Gender and age statistics of flood fatalities demonstrate that certain groups are overrepresented. Other groups such as tourists and drivers, particularly of four-wheel-drive (4WD) vehicles, have also been identified as being more vulnerable. Demographic profiles link with both risk perception and social influences discussed previously.

1) GENDER

There is significant overrepresentation of male fatalities from flooding in studies where gender was reported (Ashley and Ashley 2008; French et al. 1983; Jonkman and Kelman 2005; Kundzewicz and Kundzewicz 2005; Mooney 1983; Sedwick 2008; Diakakis and Deligiannakis 2013; Doocy et al. 2013; Petrucci and Pasqua 2012). Coates (1999) determined that in Australia between 1788 and 1996, males accounted for 80.6% of flood fatalities, which translates into a male to female death ratio of 4:1 (Coates 1999). For the period of 1950–2008 in Australia, 68% of 180 flash flood fatalities (where gender was recorded) were male (Coates and Haynes 2008). In more recent years, 1997–2008, this figure rose to 71% of all flood-related deaths in Australia (FitzGerald et al. 2010).

Jonkman and Kelman (2005) found the same overrepresentation of male flood fatalities in the United States and Europe. Men were found to be overrepresented in vehicle crashes, drowning and physical trauma, and pedestrian drowning (Jonkman and Kelman 2005). Several factors have been identified as contributing to the high proportion of male fatalities, such as the large number of males who drive, high proportions of males who work for emergency services, and a propensity for risk-taking behavior (Coates 1999; Coates and Haynes 2008; FitzGerald et al. 2010; Jonkman and Kelman 2005).

2) AGE

The literature also identified age profiles of more vulnerable populations (Ashley and Ashley 2008; Coates 1999; Coates and Haynes 2008; FitzGerald et al. 2010; French et al. 1983; Jonkman and Kelman 2005; Mooney 1983). Those between the ages of 10 and 29 and over 60 years of age are overrepresented in the flood fatalities statistics. In the United States, French et al. (1983) and Mooney (1983) determined increased vulnerability for those <21 and >60 years of age. Sedwick (2008) noted increased vulnerability for those in the 20–29 and the >60 age groups and Ashley and Ashley (2008) in the 10–29 and >60 age groups. In Australia during the years of 1950–2008, those most at risk of being flash flood victims were in the age brackets of 0–9, 10–19, and 20–29 years old (Coates and Haynes 2008; FitzGerald et al. 2010; Wright et al. 2010). Shabanikiya et al. (2014) found that young people (18–35) were more likely to indicate they would attempt to cross floodwater in a future flood. As well as the young being overrepresented in flood deaths, older people have also been found to be more vulnerable. In recent (1997–2008) Australian flood fatalities, FitzGerald et al. (2010) found an overrepresentation of those over 70 years.

The overrepresentation of young people (20–29) corresponds with tendency toward elevated risk taking behavior in this age group (Jonah 1986; Maples and Tiefenbacher 2009). The trend of the elderly (>60) and the very young (0–4) perishing is linked to their decreased ability to flee (Coates 1999; Coates and Haynes 2008). Jonkman and Kelman (2005) determined that half of the drownings that occur in buildings are individuals over the age of 60. This was illustrated well by a storm surge on the Atlantic coast of France in 2010 that breached floodwalls, resulting in the rapid flooding of nearby coastal towns. The majority (71%) of the 41 flood victims were women over the age of 60 who were surprised in their sleep and died in or near their homes (Vinet et al. 2012).

One Greek study on vehicles driving into floodwater has found a different association with age and flood

fatalities. Diakakis and Deligiannakis (2013) found most victims of vehicle-related flood deaths in Greece to be between 40 and 69 years old, rather than young or elderly.

3) TOURISTS

Tourists have also been suggested to be a more vulnerable group due to their unfamiliarity with the local environment. A few studies have examined whether or not tourists are more susceptible to flooding specifically (Gruntfest 1977; Ruin 2008), while others have focused on tourism and other hazards (Orchiston 2009; Drabek 1994; Johnston et al. 2007). Events such as flash flooding, and even riverine floods, may surprise tourists and it can be difficult for them to access information about the nature of the event, how it will affect them, and therefore how they should respond (Drabek 1994; Johnston et al. 2007; Kelman et al. 2008).

On the other hand, Faulkner and Vikulov (2001) observed that tourists have qualities that made them more resilient. In their study of the 1998 Australia Day flood at Katherine in Australia, tourists proved to be less vulnerable than residents since they had no emotional attachment to the location and therefore experienced less trauma and were able to make decisions more easily (Faulkner and Vikulov 2001). Similarly, Ruin (2008) found that tourists are more likely to do the right thing in floods even if warnings hardly reach them. She suggests that this occurs because residents tend to act according to their knowledge of the environment while tourists follow standard safety procedures (Ruin 2008).

4) DRIVERS

In the United States, the majority of flood deaths (76%) involve motor vehicles (Sharif et al. 2010). In Texas, which has 3 times the number of fatalities of any other state, 77% of the 616 fatalities where circumstances are known were motor vehicle related in the period of 1959 to 2008 (Sharif et al. 2010). In contrast, Jonkman and Kelman (2005) found that only 27% of European flood deaths are vehicle related compared to 63% in the United States. In Australia between the years of 1997 and 2008, the use of a motor vehicle was involved in 49% of flood fatalities (FitzGerald et al. 2010). In terms of the nature of vehicle-related flood deaths, one study found that many deaths occurred when victims abandoned their vehicles in floodwater (46%) or when occupants suffered trauma in a car accident caused by urban flooding (23%) (Petrucci and Pasqua 2012).

Drivers of four-wheel-drive vehicles have been found to be vulnerable based on their increased voluntary exposure to floodwater. Research in the United States

has found that those who drive trucks or sports utility vehicles (SUVs) are more likely to self-report or be observed driving in the floodwater (League 2009). A reliance on thinking a large vehicle such as a SUV is sturdy or safe may lead people to undertake inappropriate behaviors around flooding (Franklin et al. 2014; Maples and Tiefenbacher 2009; Petrucci and Pasqua 2012).

d. Temporal and environmental factors

In addition to demographic factors, certain temporal and environmental factors can influence voluntary entry into floodwater.

1) TIME OF DAY, SEASON, AND CONDITIONS

Temporal factors have been found to correlate with floodwater entry resulting in higher incidences of fatalities. Vehicle-related deaths are common at night (Sedwick 2008; Maples and Tiefenbacher 2009; Sharif et al. 2010). The amount of natural light has been found to be a major factor in influencing visibility and it is difficult to judge the depth and speed of flowing water at night when driving (Maples and Tiefenbacher 2009). Two separate studies in the United States that examined vehicle-related flood deaths in Texas during 1950–2004 (Maples and Tiefenbacher 2009) and 1959–2008 (Sharif et al. 2010) found higher numbers of fatalities at night time. Of the 140 incidents where the time of day was known (44), Maples and Tiefenbacher (2009) determined that 25% of these occurred in the daytime, 14% at dusk/dawn, and 61% at night. Sharif et al. (2010) found similar figures in their study for incidents where the time was reported (346 of 471 incidents): 56% occurred at night, 17% in the afternoon, and 27% in the morning (Sharif et al. 2010). The results are mirrored in a Greek study where more vehicle-related flood deaths (46%–67%) occurred at night time (Diakakis and Deligiannakis 2013).

The type of flood can also be correlated to the time of day. Flash flood deaths occur mostly at nights while riverine deaths are more common in the day (Sedwick 2008).

There does not appear to be a trend in the United States with regard to seasonal fatality patterns (Ashley and Ashley 2008; Kellar and Schmidlin 2012). Also, Italian research by Petrucci and Pasqua (2012) did not find a straightforward relationship between rainfall characteristics and flood-related injury or death. In Australia, however, most flood-related deaths occur in the summer, with February as the peak month (FitzGerald et al. 2010). Summer storms in the northeast of Australia are more often associated with flash flooding and therefore more likely to result in fatalities.

2) ENVIRONMENTAL FAMILIARITY

The role that a person's familiarity with the environment plays has already been discussed in detail in section 3b(1). To reiterate, environmental familiarity may cause individuals to underestimate risks and make people more likely to voluntarily enter floodwater (Maples and Tiefenbacher 2009; Petrucci and Pasqua 2012).

3) PHYSICAL CUES WITHIN THE ENVIRONMENT

In terms of thinking about physical cues located within the environment, initiatives such as signage and barricades are often used to deter people from entering floodwater. A study by Coles et al. (2009) examined the effectiveness of signage and barricades in deterring people from driving into floodwater. From their survey in Tucson, Arizona, they found that signs and barricades do not often deter motorists from entering floodwater. Signs and barricades can be ambiguous because they are not present at all intersections and can remain in place when streets are dry. Ninety percent of respondents felt the *likelihood* of flash flood danger was indicated by the presence of a sign or barricade, but less than half felt the *degree* of flash flood danger was communicated (Coles et al. 2009). Respondents who suggested they had not driven into the floodwater reported slightly higher levels of trust in signs and barricades than those who had driven into the waters (Coles et al. 2009).

e. Making the links: Understanding how the "puzzle pieces" fit together

Piecing together the results from the preceding literature review, it is possible to develop a diagram of influences on voluntary floodwater entry (Fig. 1). As discussed already, risk perception and social influences have a key impact on people's decision-making about whether to enter floodwater or not, and the types of actions they take. Aspects such as optimistic bias (Weinstein 1980), normalization bias (Mileti and O'Brien 1992), environmental and temporal factors, and demographics feed into both risk perception and social influences.

This diagram shows a simplistic version of some of the themes that were picked up by the literature review. The linkages and relationships between these themes are complex and require further investigation. Indeed, even an aspect such as risk perception has been well studied and found to be highly complex and interactive (Renn et al. 1992; Slovic 2000; Lindell and Perry 2012). The themes identified in the literature review would benefit from consideration within a broader model such as the Protective Action Decision Model (PADM; Lindell and Perry 2012), which considers people's responses to environmental hazards and disaster. This model has been

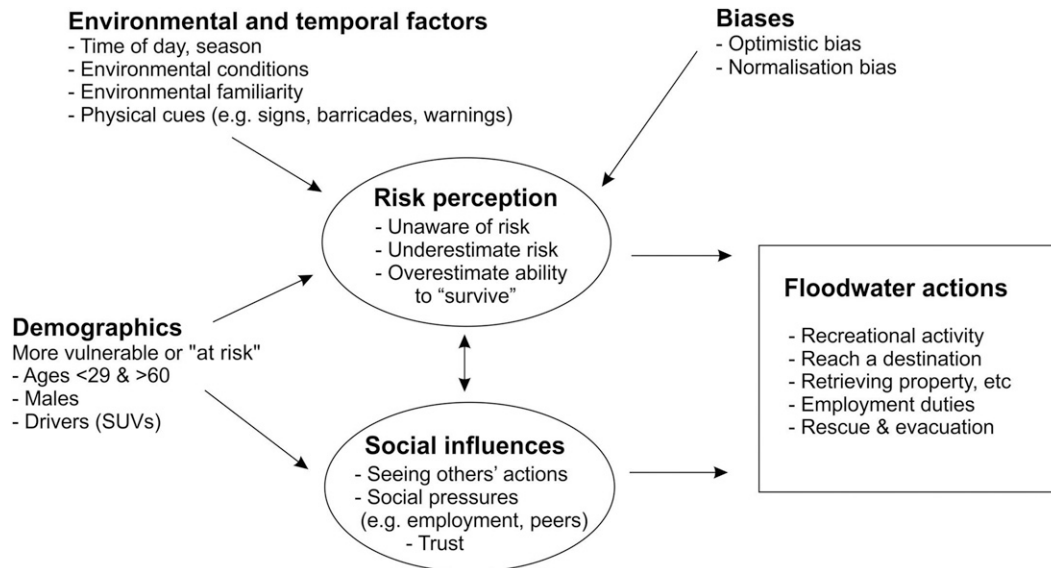


FIG. 1. Influences on voluntary floodwater entry.

applied in a flooding context before with respect to preparedness (Terpstra and Lindell 2013) and across a range of hazards in terms of preparedness and response (Lindell and Perry 1992, 2000, 2012). The model already includes many of the themes that have been highlighted in this paper as important in the decision-making process. These include environmental and social cues, information sources and warnings (e.g., in the context of signage and barricades), predecision processes, risk perception (threat, protective action, and stakeholder perceptions), and behavioral response. More targeted research work could be undertaken to verify the findings from this literature review, scope out further reasons as to why people enter floodwater, and frame it within the context of an existing behavioral model such as the PADM.

4. Discussion

Given that people continue to voluntarily enter floodwater (to undertake recreational activities, retrieve personal items, attempt to reach a destination, assist with rescuing and evacuation, and for employment reasons), it is evident that effort is still required to prevent people from floodwater entry. Emergency managers should focus on developing effective plans and public education programs to address this issue. The issue of floodwater entry could be incorporated into a generic plan or education program for flooding, or could be addressed specifically. A wide variety of methods should be implemented including information provision, messaging, community engagement, warning systems, signage, and physical infrastructure. In achieving

the goal of appropriate behavior around floodwater it is important that communities and organizations work together in partnership (Finnis 2004, Finnis et al. 2007). This includes community members, emergency managers, local authorities, the media, and other relevant organizations.

Our literature review found several existing education programs that had a specific focus on deterring people from entering floodwater. These included the U.S.-based "Turn Around, Don't Drown" (NOAA National Weather Service 2006), Ditch Playing in Ditches (City of Colorado Springs 2010), Clark County Regional Flood Control District (CCRFC) (Clark County Regional Flood Control District 2009), "Ditches are Deadly: Swim and Play in Safe Places" (Ditch and Water Safety Task Force 2014) awareness campaign, and the previously existing Australian-based Mates for Life (M8s4life) program (Gold Coast City Council 2008) (Table 1). However, despite the presence of such education campaigns, no documented evaluation of these initiatives exists. Thus it is difficult to say what kind of impact they are having on changing people's behavior in the long term. Evaluation is key to understanding whether a program is having a positive impact or not.

For those who have yet to develop planning and public education initiatives for entering floodwater, our findings point to a number of specific recommendations that should be considered.

a. Address risk perception

First, it is evident that risk perception, either directly or indirectly, has an influence on actions taken. While

TABLE 1. Examples of public education programs that have a specific focus on deterring people from entering floodwater.

Public education program	Details
“Turn Around, Don’t Drown” (TADD)	TADD is a campaign operated by the United States’ National Oceanic and Atmospheric Administration (NOAA) National Weather Service. Its intention is to warn people of the dangers of walking or driving a vehicle through floodwater. Its key components are signage permanently stationed at low points in roads that flood in extreme rainfall events and a web page that includes a brochure and presentation resources (NOAA National Weather Service 2006).
“Ditch Playing in Ditches”	The city of Colorado Springs, Colorado, in the United States instigated their “Ditch Playing in Ditches” campaign following the drowning of two children in the town. The program specifically targets children playing in areas that may be inundated during flash floods. The campaign is web-based providing resources for teachers and parents and videos and games for children (City of Colorado Springs 2010).
“Ditches are Deadly: Swim and Play in Safe Places”	The “Ditches are Deadly: Swim and Play in Safe Places” program run in New Mexico encourages children not to play in drainage areas (i.e., the arroyo system) where flash flooding can occur, or in ditches full of water. It provides safe alternative locations where children to go and play instead, such as parks and pools. The program uses a partnership approach between different agencies, and presentations and special events are organized to encourage appropriate flood-related behaviors (Ditch and Water Safety Task Force 2014).
Clark County Regional Flood Control District (CCRFCD)	Clark County Regional Flood Control District in Texas launched an annual billboard competition in 2003 for the public to submit ideas for roadside billboards featuring witty number plate messages and inundated vehicles. In addition, the CCRFCD has conducted an annual survey of people’s awareness and behaviors around flash flooding, including whether people had entered the floodwater (in vehicles) and why. Despite the decrease in the number of people entering floodwater in vehicles in the county, it is difficult to determine whether it is the billboard campaign that is influencing people’s decision making process because the survey asked people why they choose to enter, not why they choose to avoid the floodwater or wait until it subsides. Nevertheless, over 50% of respondents report billboards as one of their flood information sources (Clark County Regional Flood Control District 2009).
“Mates for Life (M8s4life)”	The Australian school-based program called “Mates for Life” was designed by Gold Coast City Council and primary school educators to inform children in years three to seven about the dangers of playing in flood and storm waters. The program was delivered through a variety of media and has key messages of “Stay away from stormwater” and “The water could be deep, fast flowing, or contain objects that can hurt you” (Gold Coast City Council 2008). The program was assessed through normal school curriculum methods.

people are generally aware of flood risk, it is clear that people continue to be unaware of or underestimate the actual dangers posed by floodwater (e.g., that it is possible to get washed away by even a small amount of water and become a fatality) or are optimistic ([Weinstein 1980](#)) that if they do enter they will not suffer any negative effects. These types of risk perceptions can lead people to making a decision to voluntarily enter floodwater. Future public education efforts need to continue to emphasize the actual dangers and consequences of entering floodwater. A better understanding of the negative consequences of entering flooded areas may go some way toward helping encourage appropriate behavior.

b. Consider social influences

Second, social influences need to be considered in the overall mix. The influence of others’ opinions and actions is evident in forming risk perceptions and making decisions about action. Accounting for social influences in planning and education programs can be challenging,

but there are practical measures that can be taken to enhance social influence in a positive way. For example, emergency managers should acknowledge that people are information providers and receivers. Consequently they should develop and communicate information in ways that enable the “social information” process to operate effectively. To ensure effective public education about appropriate flood behavior, emergency managers should provide multiple types of information, make use of multiple transmission channels, and engage the community via existing social networks ([Lindell and Perry 2012](#)). Thought should also be given to how public education can support social norms for appropriate flood behavior, as a social norm around not entering floodwater would mean that fewer people may be motivated to enter. Trust was highlighted as an issue in the literature review, in that those who trusted signage about not entering floodwater were more likely to adhere to the message of the signage. It is evident then that trust of information (and trust in the source of information) is an important aspect in encouraging

appropriate behaviors (Paton 2007) and consequently should be developed more broadly across flood education programs.

c. Focus on vulnerable or “at risk” groups

Third, the literature revealed that demographics appeared to have an influence on risk perceptions and social interactions, and thus played a part in people’s decisions about entering floodwater. Those identified as more likely to enter floodwater voluntarily were males, and individuals between the ages of 10 and 29 or over 60 years of age. Drivers were also proven to be a more vulnerable group.

Provision should be made for working with at-risk groups who are more likely to enter floodwater. Research on vulnerable populations in other topic areas (e.g., health) has found that targeting and working with specific groups on particular topics can provide support to such populations and help change attitudes and behaviors in a positive way (Soole et al. 2007; Howat et al. 2001; Hill 1998; Finnis 2004). Some of this specific work will need to focus on changing social norms, as much of the risky behavior exhibited by certain demographic profiles is linked with a social norm that entering floodwater is acceptable (e.g., for the purposes of having fun; or the fact other people are seen entering the water so it must be an appropriate action).

Another subset of people identified as likely to enter floodwater are those who work in specific occupations (e.g., emergency services, utility maintenance workers, mail delivery personnel, and miners). A good avenue for addressing the issue of floodwater entry with these people would be through workplace health and safety initiatives. There is a role for workplace health and safety to assist with education about the dangers of floodwater entry, the development of skills to assist with appropriate decision-making when faced with floodwater, physical training for floodwater situations, and the provision of appropriate safety equipment if floodwater entry is in fact required as part of the role.

d. Ensure an effective warning system integrated with public education initiatives

Fourth, while there has been little discussion about warning systems in this paper thus far (from hardware to human behavioral response), they still remain an important element in reducing flood risk. Warnings systems play a significant role in influencing people’s behavior around floodwater. A considerable amount of literature exists around people’s perceptions of, and responses to, warning systems (i.e., warning messages, information, sirens, alarms, and evacuation orders) for various hazards including flooding (Aguirre 1991; Balluz

et al. 2000; Bateman and Edwards 2002; Benight et al. 2007; Parker et al. 2007; Brown and Damery 2002; Dow and Cutter 1998; Drabek 1999; Handmer 2000; King 2007; Mileti 1995; Mileti and Sorensen 1990; Sorensen 1991, 2000). Research of warning systems, however, has found that warnings alone are less effective in saving lives than previously thought because “context is everything” (Parker et al. 2007). That is to say that people do not generally take protective action upon hearing a warning, but rather they undergo a social psychological process to form their own impressions of the risks they face and ideas of what they will do before responding (Mileti 1995; Parker et al. 2009). Elements of both the warning system itself—its source, accuracy, consistency, clarity, frequency, certainty, and the channel of communication used—and the factors pertaining to the recipients—their previous experience, their sociodemographic background, the social context in which the message is received, the ability to confirm the warning through various channels, environmental cues, and the perception of responsibility—have been found to influence people’s responses to warnings (see Brown and Damery 2002; Mileti 1995; Mileti and Sorensen 1990; Parker et al. 2009). Each of these aspects must be considered when attempting to develop effective warning systems and, more broadly, effective flood education.

Connections should be made between educational efforts undertaken prior to flooding, and the warnings given at the time actual flooding is imminent or present. For example, in thinking about the issue of people “trying to get to a destination” during a flood, public education prior to an event could outline the severe consequences of entering floodwater and promote the message of not ever entering floodwater. The time period before an event could also be used to help the community identify alternative routes to take when flooding does occur. People could help map these routes and practice taking these routes during a safety exercise. When an event actually occurs, what people have learned prior to the event should be reinforced by the subsequent communications and activities that take place during the event itself. For example, road closure information and detour information (including messages in the media, relevant signage, and barriers) need to be used consistently with what people have learned about prior to an event to support their decision-making. This will ensure that people do not make inappropriate choices when trying to get to a destination during a flood.

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