STUDENT PAPER COMPETITION
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Public Perceptions of Flash Flood False Alarms: A Denver, Colorado Case Study

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Natural hazard warning responses are affected by many factors. One factor that academics and practitioners debate is the effect of false warnings or false alarms. Few studies have documented the effects of false alarms. The conventional wisdom is that false alarms are problematic and result in reduced response rates. Newspaper titles of "The blizzard that wasn't", "The snow that didn't fall" and "False alarms cry wolf" demonstrate this common notion. Yet, some research shows that false alarms do not reduce peoples' willingness to take protective actions in future warnings if there is an understanding of the event and of the reason for the warning (Dow & Cutter, 1998; Dow & Cutter, 2000).

This paper aims 1) to examine false alarm perceptions of Denver floodplain residents and 2) to identify how gender and age affect perceptions of false alarms. Findings from this study can be used by the National Weather Service and others involved in warnings to improve communication and increase the likelihood that warnings will be heeded and responded to appropriately.

Literature Review

Warning Systems

Warnings systems and warning dissemination have a great potential to reduce loss of life in hazards. For warnings to be effective, several steps or conditions need to occur. Mileti and Sorensen (1990) outline six necessary steps for people to respond to a warning. These steps are 1) to hear (receive) the warning, 2) to understand the meaning of the message, 3) to believe the warning is accurate and credible, 4) to personalize the message, 5) to confirm the warnings and 6) to respond to the warning by taking protective actions. If these six steps are adhered to, warning response should increase and loss of life in hazards should decrease.

Demographic influences in warning response

Since the 1960's multiple studies have considered how the demographic characteristics of age and gender influence warning perceptions and response. Appendix A is a summary of hypotheses made by some of the researchers who have examined the effects of gender and age.

Previous disaster research that has focused on gender has found that women have higher levels of risk perception, higher levels of preparedness, and are more likely to believe warning messages than men (Mack & Baker, 1961; Cutter et al., 1992; Fitzpatrick & Mileti, 1994; Flynn et al., 1994; Alway et al., 1998; O'Brien & Atchison, 1998; Enarson & Scanlon, 1999; Enarson & Scanlon, 1991; Major, 1999). Risk perception has been documented to be the strongest predictor of evacuation compliance

(Perry et al., 1981). While many researchers have considered the influence of gender, Enarson has primarily focused on the need to examine disasters "through women's eyes" (Enarson & Scanlon, 1999). Enarson and Morrow's book, *The Gendered Terrain of Disaster,* is a compilation of case studies in which the objective of "integrate[ing] women and gender equity into all aspects of disaster planning, response, recovery, and mitigation" is a primary focus (1998: xii).

While some previous disaster research that has focused on age indicates that older populations are less likely to receive warnings, (Friedsam, 1962; Hutton, 1976) are less likely to take protective actions, (Mileti et al. 1975) and are more likely to experience death or injury in a disaster, (Friedsam, 1962; Trainer & Hutton, 1972; Hutton, 1976) other research has found that older people are not any less likely than people in other age groups to take protective actions (Drabek & Boggs, 1968; Drabek, 1983). Increased vulnerability of older populations has been attributed to a lack of informal community and kin networks as a means for receiving warnings (Perry et al., 1981; Perry, 1985).

Although many researchers have examined the influence of demographic characteristics of gender and age on warning response, there is not total agreement as to how demographic factors influence warning response and perceptions of warnings. For example, several research efforts have found the elderly to be more vulnerable to hazards because they are less likely to receive warnings, less likely than people in other age groups to believe warnings and require a larger effort to convince them to take protective actions than people in other age groups (Friedsam, 1962; Hutton, 1976), yet other research has found that older people are not any less likely than people in other age groups to take protective actions (Drabek& Boggs, 1968; Drabek, 1983). Due to a non-consensus of the influence of demographic characteristics in warning response and the lack of research in how demographic characteristics influence false alarm perceptions, there is a need for future research to examine how demographic characteristics influences perceptions of warnings and false alarms.

The Effects of False Alarms & the "Cry Wolf" Concept

The concept that false alarms reduce willingness to respond has come to be known as the "cry-wolf" effect. This concept has been adapted from Aesop's fable of "the boy who cried wolf." The actual effects of false alarms on populations are debatable. A consensus of how false alarms impact individuals and society has not been reached (Janis, 1962; Drabek, 1986; Dow & Cutter, 1998; Dow & Cutter, 2000; Pielke & Sarewitz, 2000; Carsell, 2001; Gruntfest, Carsell, & Plush, 2002). Findings from the workshop *Extreme Events: Developing a Research Agenda for the 21st Century* conclude that scientific predictions benefit the decision-making processes, but that predictions themselves have societal impacts. Sarewitz and Pielke (2000) suggest that incorrect predictions, or false alarms, have significant cost and they do affect individuals' and institutions' willingness to respond in future events. One study of a dam failure false alarm in California found that while false alarms may create frustrations for individuals, false alarms do not reduce willingness to respond. Rather, they can provide opportunities to learn appropriate responses in future warnings (Carsell, 2001).

Social scientists from the disciplines of geography, sociology, psychology and economics, have contributed knowledge to understanding the effects of false alarms. Several economists have focused on the financial cost of false alarms, factoring a monetary cost of false alarms into their analysis (Cox, 1979; Papastavrou & Lehto, 1996; Roulston & Smith 2004). A psychologist, Breznitz, focused on physical reactions to repeated false alarms in a laboratory setting, finding that repeated false alarms reduce willingness to respond (1984). However, this research is limited in that it does not take into account the effects of social context or media (Drabek, 1986: 77-78). Sociologists have examined how individuals function within social contexts in disasters (Drabek et al.1975;

Drabek, 1986; Mileti, 1990; Enarson & Scanlon, 1991; Enarson & Scanlon, 1999; Major, 1999; Drabek, 2001). Geographers have examined false alarm case studies in specific regions and warning response in relation to environmental factors and perceptions (Dow & Cutter, 1998; Dow & Cutter, 2000; Carsell, 2001; Gruntfest, Carsell, & Plush, 2002).

While there is much debate about how the public responds to false alarms, research has found that false alarms and close calls can be beneficial for emergency personnel. False alarms can provide an opportunity for practical training opportunities and insight into improvements in protocol (Gruntfest & Carsell, 2000; Weaver, Gruntfest & Levy, 2000; Rhatigan, Gruntfest & Barnes, 2004). Rhatigan *et al*. (2004) found that although emergency management personnel's confidence is not lessened by false alarms, they perceived that the public's confidence would be lessened by false alarms.

How realistic are the perceptions and the conventional wisdom about false alarms? In 1996 Dow and Cutter examined the near misses in South Carolina for Hurricane Bertha and Hurricane Fran as actual repeated false alarm situations. In both hurricanes, North Carolina and South Carolina were ordered to evacuate, but both storms made landfall in North Carolina, missing most of South Carolina (1998). Dow and Cutter's study evaluated how these repeated near misses influenced public perceptions of false alarms and willingness to evacuate. Respondents indicated that official calls to evacuate were just one factor among many that influenced their decision of whether or not to evacuate. Respondents were not negatively impacted by the repeat evacuations and indicated that they would consider personal factors and utilize several sources of weather information to make future evacuation decisions (Dow & Cutter, 1998). It is also important to consider that a hurricane is a long-fuse hazard that can be monitored over a period of time before the impact, so the public has time to consider many different factors and sources of information.

Other studies have indicated that many people look to multiple sources to confirm a warning prior to taking action (Carsell, 2000; Gruntfest, Carsell & Plush, 2002). False alarms may create a higher level of vigilance to follow the next warning more closely. This is particularly so if a community becomes informed of the possible risk and of their personal vulnerability (Janis, 1962: 84-86).

Denver, Colorado Case Study

This paper is an edited version of a thesis conducted as a part of the three-year "Warning Project." Denver, Colorado was chosen as the location for one of the case studies outlined in the Warning Project's grant proposal for the following three reasons: 1) there is a history of floods and of flood rescues; 2) the city has experienced rapid growth in the past 35 years; and, 3) the city has a diverse population and is close to Colorado Springs for convenience of access to the surveyed population.

Research Questions

The two research questions for this paper are the following: 1) Is there a "cry wolf" effect for flash flooding? and 2) How do demographic characteristics of gender and age affect perceptions of false alarms? The conventional wisdom that false alarms reduce willingness to respond to future warnings influences officials responsible for issuing warnings and influences when to issue warnings. These research questions need to be addressed to determine if public perceptions of false alarms are the same as the conventional wisdom. It is also important to consider how demographic characteristics of a population affect false alarm perceptions. Understanding differences in false alarm perceptions between men and women and between younger and older residents can enable officials to target messages to diverse groups and effectively communicate to all people at risk.

Methodology

Extensive survey questionnaires were developed as part of the National Science

Foundation "Warning Project" with the cooperation of emergency managers, individuals with The National Weather Service, and academics who have experience in hazards or in survey techniques. The surveys were mailed out between September 2004 and January 2005.

Sample selection

The Warning Project aimed to obtain a representative sample of residents identified as living in the flood plains in Denver, Colorado. A total of 2,800 potential respondents who live in, or directly next to Federal Emergency Management Agency (FEMA) defined floodplains, were randomly selected from a database provided by the Urban Drainage and Flood Control District in Denver.

Census data were also used to identify the zip codes within the floodplain database with the highest percent of Hispanic residents. For these areas, a Spanish language and an English language survey were sent out. English language surveys were sent to randomly selected addresses in the zip codes with the lowest percent Hispanic. The Dillman (2000) method was utilized to enhance the response rate. The Dillman method included a pre-postcard, a survey with a cover letter, a reminder postcard, and finally, a new survey was sent to those who had not responded to the first mailing.

A second mailing was sent to a random selection of residents in the zip codes not used in the first mailing to increase the total number of completed surveys. Due to the low response rate following our reminder postcard and second mailing to the first sample group, we did not follow Dillman's (2000) recommendations completely for the second major mailing. This mailing included a pre-post card and a cover letter with the survey, but did not include a reminder post-card or another survey. The overall response rate was 16.5% from both the first and second mailings. (Gruntfest & Benight 2005). Figure l shows the location of respondents. Of note are the clusters along particular floodplains in Denver.

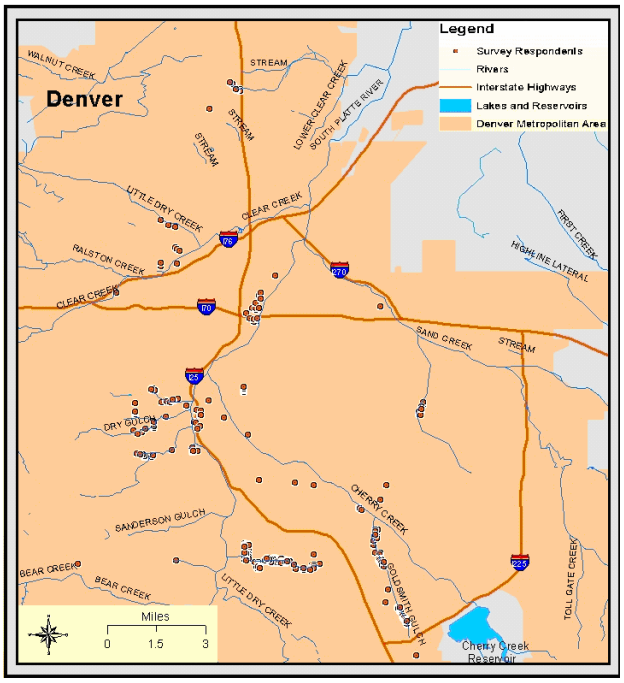

Figure 1: Location of Survey Respondents

The survey questions analyzed in this paper are:

1. Realizing it's difficult to predict flash floods, I would prefer more warnings even if it means there are more false alarms or close calls.
2. One or two false alarms or close calls would reduce my confidence in future warnings.

These questions address the concept of "cry-wolf" as discussed earlier. Determining if the cry-wolf concept is accurate can provide insight for officials in establishing when warnings should be issued. The response options were based on a Likert scale and worded "strongly agree", "agree", "disagree", and "strongly disagree." Data have been combined into agree and disagree to conduct Chi-square test of independence. Findings are presented in frequency charts and Chi-square tests of independence to determine overall perceptions and correlations with demographic characteristics.

Results

This paper examines false alarm perceptions of 419 floodplain residents in Denver who responded to a mail survey.

Preference for More Warnings

Conventional wisdom indicates that over-warning can reduce willingness to comply with future warnings. Our respondents indicated that they would *prefer* more warnings even if it means that there are more false alarms or close calls. Figure 2 shows that 78% agreed with this statement and only 22% disagreed. These findings support previous research that false alarms do not reduce willingness to respond in future warnings (Carsell, 2001; Gruntfest & Carsell, 2000; Dow & Cutter, 1998).

While the responses to this survey question can indicate strong support that over warning may not reduce confidence in future warnings, there can be complications with interpretation of this question and further research should address the differences between what people say they will do in a given situation versus what their behaviors actually would be in the given situation.

Preference for More Warnings: Effects of Gender

Figure 3 shows that whereas the majority of people prefer more warnings, there is a significant statistical difference between men and women. More men disagreed with this statement than women, and more women agreed with this statement. Using the Chi-square test of independence this difference was significant (X^2 =.011, p <.05). The difference in preference for more warnings between men and women may indicate that men are less tolerant of false alarms and are more likely to disregard warnings.

Preference for More Warnings: Effects of Age

Figure 4 shows that generally older individuals agree to a larger extent with this statement, and the younger respondents disagreed more. Using a chi-square test of independence, this difference was significant (X^2 =.005, p <.05). Older survey respondents indicated a need for more warnings, particularly in respondents 76 and above. Nearly one third of the respondents in the youngest range, 18-35, disagreed that there is a need for more warnings. This age group showed the greatest disagreement out of all the age groups. The largest differences in warning perception are seen between the oldest age group of 76 and above and youngest age group of 18-35. There is not a perfect linear relationship when examining the effects of age, yet there are significant differences between older respondents and younger respondents.

False Alarms do not reduce confidence in future warnings

The conventional wisdom among forecasters and emergency managers is that false alarms reduce people's willingness to respond and their confidence in the warning process. Figure 6 shows that, on the contrary, most respondents did *not* feel that one or two false alarms or close calls would reduce their confidence in future warnings. This large percentage of 77% who disagree with this statement is strong evidence that the conventional wisdom of false alarms and the "cry wolf" effect for flash flood warnings need to be reevaluated.

False Alarms do not Reduce Confidence in Future Warnings: Effects of Gender

Although the majority of respondents would prefer more warnings even if it means there are more false alarms or close calls, there is a difference in responses between men and women. Using the Chi-square test of independence this difference was not significant (X^2 =.072, p <.1). However, a trend in responses is present. Figure 7 shows that more men agreed with this statement than women, and more women disagreed with this statement than men. These findings may further support disaster literature that women are more likely to believe warnings (Mack & Baker, 1961; Turner, Nigg, Paz, & Young, 1981) and have a higher level of risk perception (Cutter et al., 1992; Fitzpatrick &

Mileti, 1994; Flynn et al., 1994; O'Brien & Atchison, 1998; Alway et al., 1998; Enarson & Scanlon, 1999). With a higher level of risk perception and a greater likelihood to believe warnings women's confidence is not lessened by false alarms.

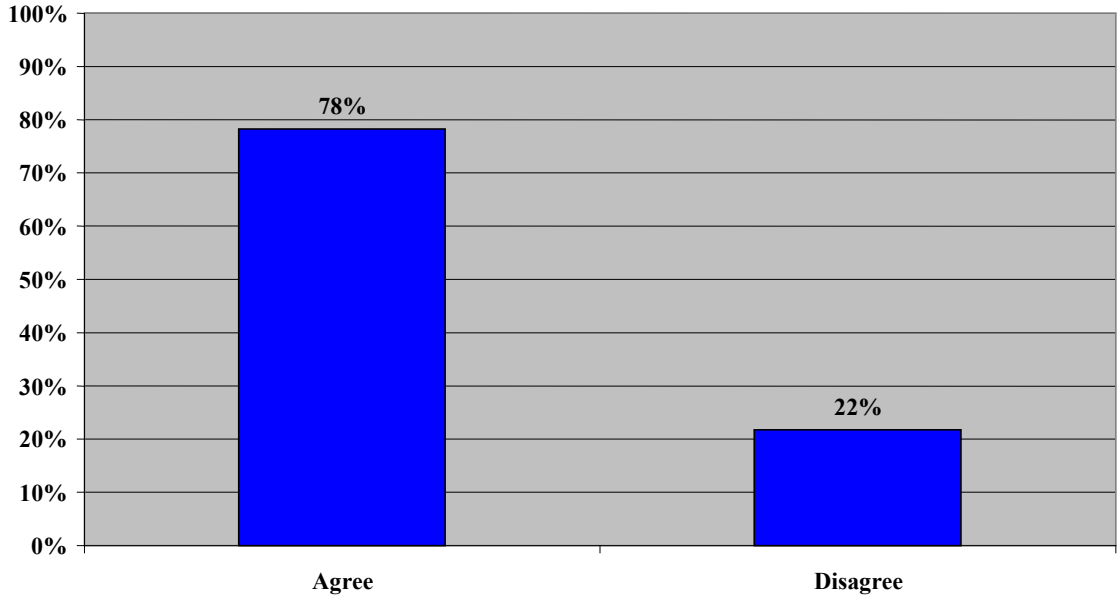

Figure 2: Realizing it's difficult to predict flash floods, I would prefer more warnings even if it means there are more false alarms (n=414)

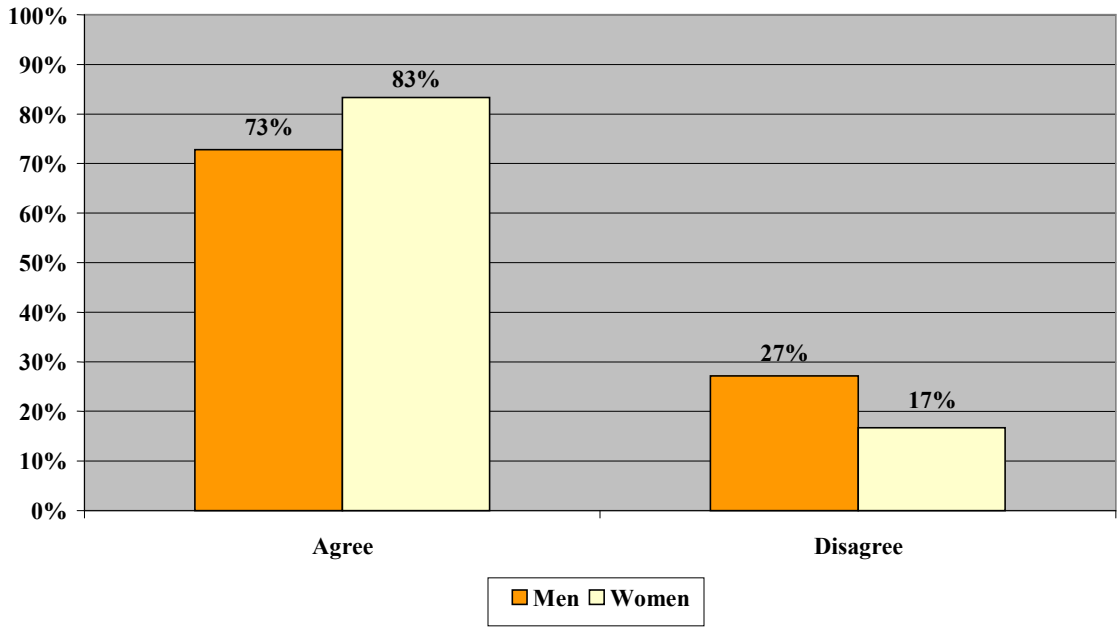

Figure 3: Realizing it is difficult to predict flash floods, I would prefer more warnings even if it means there are more false alarms or close calls: by gender (n=401)

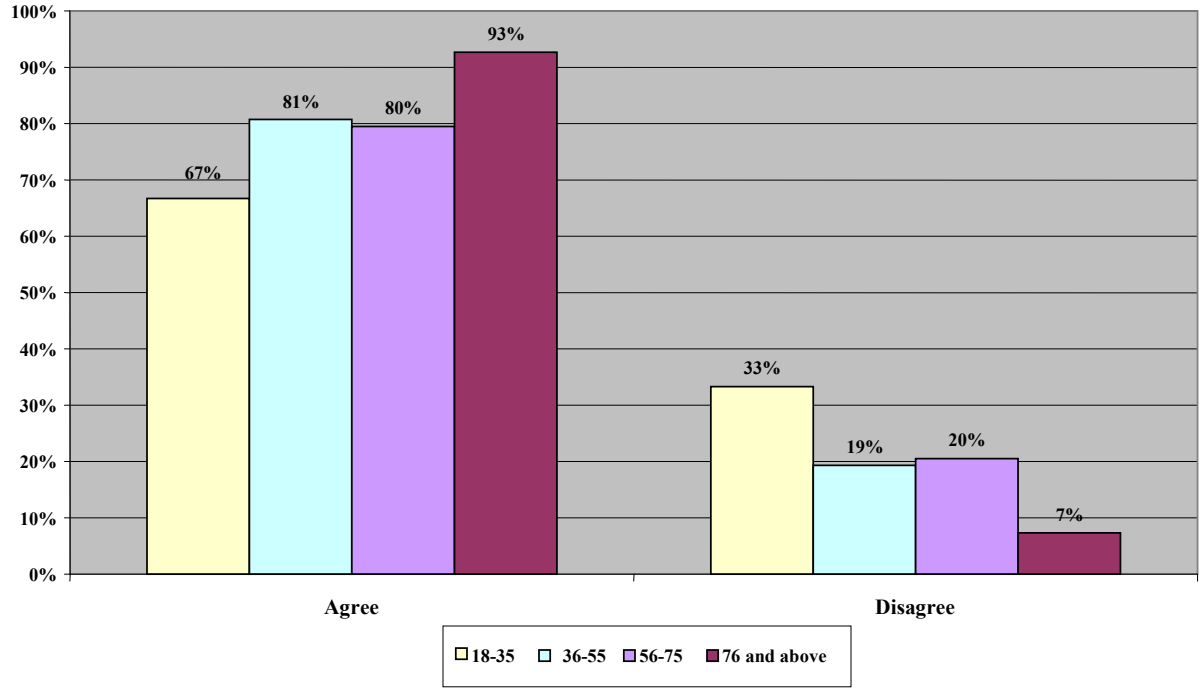

Figure 4: Realizing it's difficult to predict flash floods, I would prefer more warnings even if it means there are more false alarms or close calls (n=401)

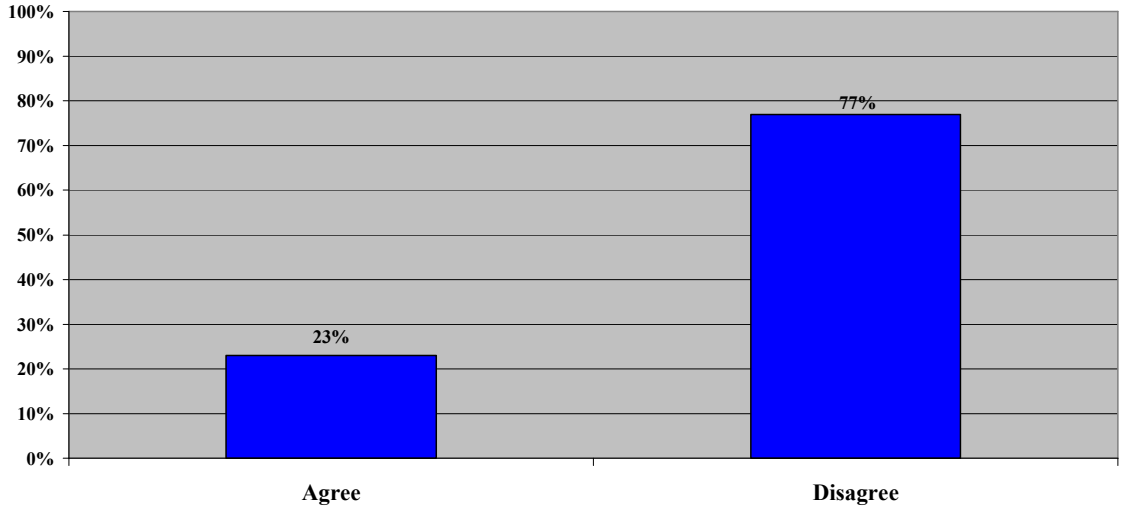

Figure 6: One or two false alarms or close calls would reduce my confidence in future warnings (n=413)

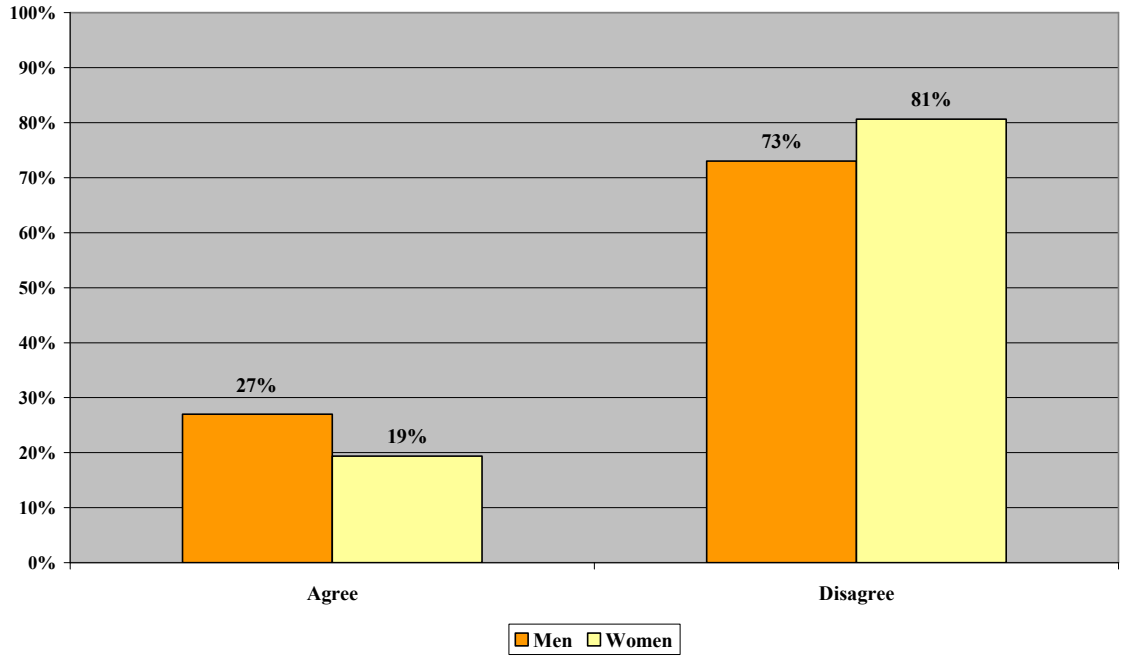

Figure 7: One or two false alarms or close calls would reduce my confidence in future warnings (n=400)

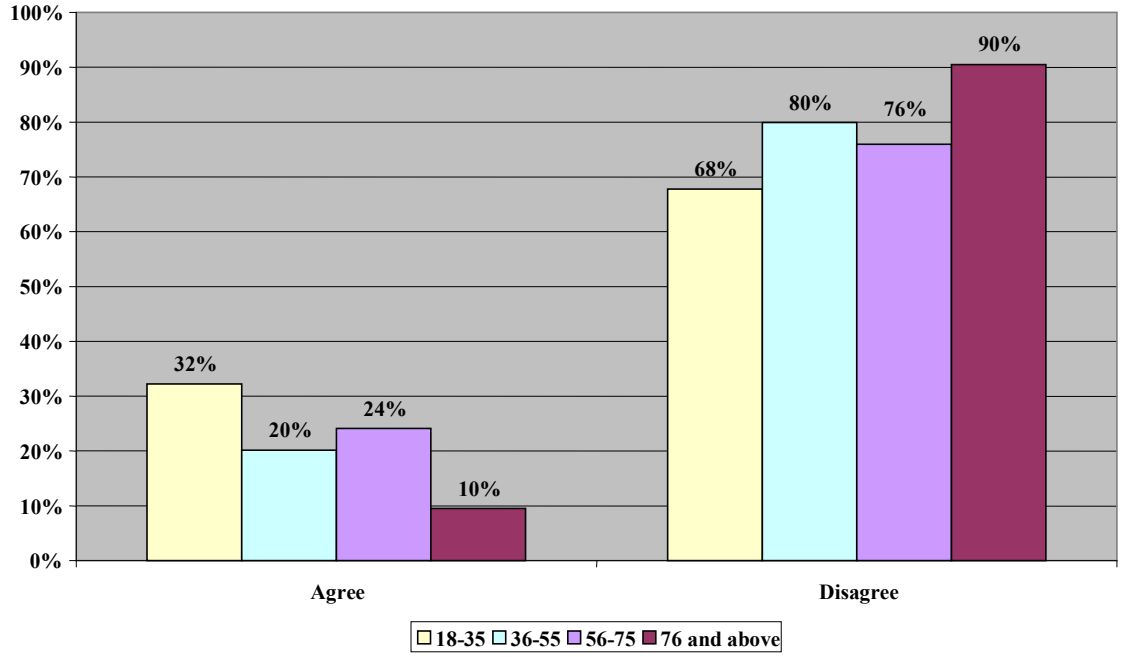

Figure 8: One or two false alarms or close calls would reduce my confidence in future warnings (n=400)

Table 1: Summary of Statistics

Realizing it's difficult to predict flash floods, I would prefer more warnings even if it means there are more false alarms or close calls.	Gender	X^2 =.011	d.f = 1	p <.05
	Age	X^2 =.005	df = 3	p <.05
One or two false alarms or close calls would reduce my confidence in future warnings.	Gender	X^2 =.072	d.f = 1	p <.1
	Age	X^2 =.025	df = 3	p <.05

False Alarms do not Reduce Confidence in Future Warnings: Effects of Age

Although the majority of all age groups disagree that one or two false alarms would reduce their confidence in future warnings, there is a statistically significant difference by age. Using the Chi-square test of independence, this difference was significant (X^2 =.025, p <.05).

Findings and Discussion

Results of the Denver case study demonstrate that the "cry wolf" effect is not as apparent in flash flood false alarms and that the public would prefer more warnings with the possibility of false alarms. When considering the effects of gender and age significant differences do arise. Although respondents in all age groups and across gender did largely agree with these conclusions, emergency managers and others responsible for issuing warnings should consider these differences in how they may affect response rates. Based on the survey results this paper has three major conclusions.

First, gender does make a difference. Previous research has documented that women have a higher level of risk perception, preparedness and vigilance when it comes to belief in warnings. These factors may explain why women would prefer more warnings with the possibility of false alarms than men, and that false alarms do not reduce women's confidence in future warnings.

Second, age does make a difference. There may not be a perfect linear relationship with age and perceptions of false alarms, yet there is a major difference between the youngest respondents between the ages of 18-35, and the oldest respondents 76 and above. The oldest survey respondents demonstrated higher levels of agreement with preference for more warnings and false alarms not reducing confidence in future warnings than the youngest respondents. Factors that may influence this difference are variation in physical ability, access to mobility, immersion in kin and family networks, and perceived ability to keep oneself safe in an emergency. Figure 8 shows that the general trend is that older respondents disagreed with this statement more. This survey question complements the previous survey question, because 91% of survey respondents over 75 years of age do not feel that false alarms reduce their confidence, where 93% of survey respondents over 75 years of age also indicate a need for more warnings.

Third, these findings mirror social trends in disasters. Those that indicate a preference for more warnings and/or false alarms not reducing confidence, women and elderly respondents, have been documented as more vulnerable populations. Women have been disproportional affected by disasters around the globe. They are more likely to die in a disaster, and women survivors are least likely to receive adequate aid and health care (Chew and Ramdas 2005). In addition to physical limitations, research indicates that elderly individuals may be more vulnerable to hazards because they are less likely to receive warnings and less likely than people in other age groups to believe warnings (Friedsam, 1962; Hutton, 1976). These populations may be aware of their increased vulnerability and thus take warnings seriously.

Conclusions and Future Research

Those responsible for communicating warnings to the public, including public officials from the National Weather Service, emergency managers, and the media are faced with many variables. They must choose appropriate

wording, be geographically and temporally as specific as possible, state levels of intensity, and they must consider a range of dissemination alternatives. Demographic characteristics of the population- at- risk influence perceptions of false alarms and how individuals will respond to future warnings.

The conventional wisdom that false alarms will reduce the public's willingness to respond in future warnings (Sarewitz & Pielke, 2000) was not seen in this Denver case study. Most of the survey respondents would prefer more warning, and they do not feel that false alarms reduce their confidence in future warnings. Yet, there is a significant statistical difference in the responses to the survey questions by gender and age. Although the differences between gender and age are small, these differences should not be overlooked by those responsible for issuing warnings. Gaining an understanding of how different demographically distinct populations perceive and react to false alarms can provide insight into how warning messages can be improved to better reach the particular segments of society and thus result in a greater warning compliance by all at risk.

This paper has examined false alarm perceptions of Denver residents who are exposed to the hazard of flash flooding, taking into account effects of gender and age. This study does not confirm the conventional wisdom that false alarms reduce confidence in the warning process and suggests the need for further research to evaluate the existence of the "cry wolf" syndrome.

Future research needs to be conducted in two particular areas. First, studies are needed to determine how other demographic characteristics influence perceptions of false alarms, if false alarm perceptions vary by geographic location, and if populations exposed to multiple false alarms are distinct from populations who have not experienced false alarms.

Second, future research should also be conducted to examine the current definition and evaluation of false alarms and other alternative methods for evaluating false alarms. This is the area of research that I will pursue in future studies. I have developed a new conceptual model that may be useful in changing how we see "false alarms." How many "false alarms" truly result in no severe weather? How many warnings are truly "close calls"? How do "close calls" fit into the spectrum of warnings as a way to establish the need for a new metric system to evaluate false alarms? My model, Appendix B, uses examples of false alarms and close calls. It was presented at two professional meetings in 2005 (Barnes 2005a, April; Barnes 2005b, April).

Findings from this study indicate a need for reconsideration of current evaluation of false alarms. Emergency managers have noted that reluctance to issue warnings is in part because of the perceived "cry wolf" effect on the public (Rhatigan, Gruntfest & Barnes, 2004), whereas the respondents in this study did not confirm the conventional wisdom that false alarms result in the "cry wolf" effect. Further research on false alarms can help improve warning responses and reduce hazard losses.

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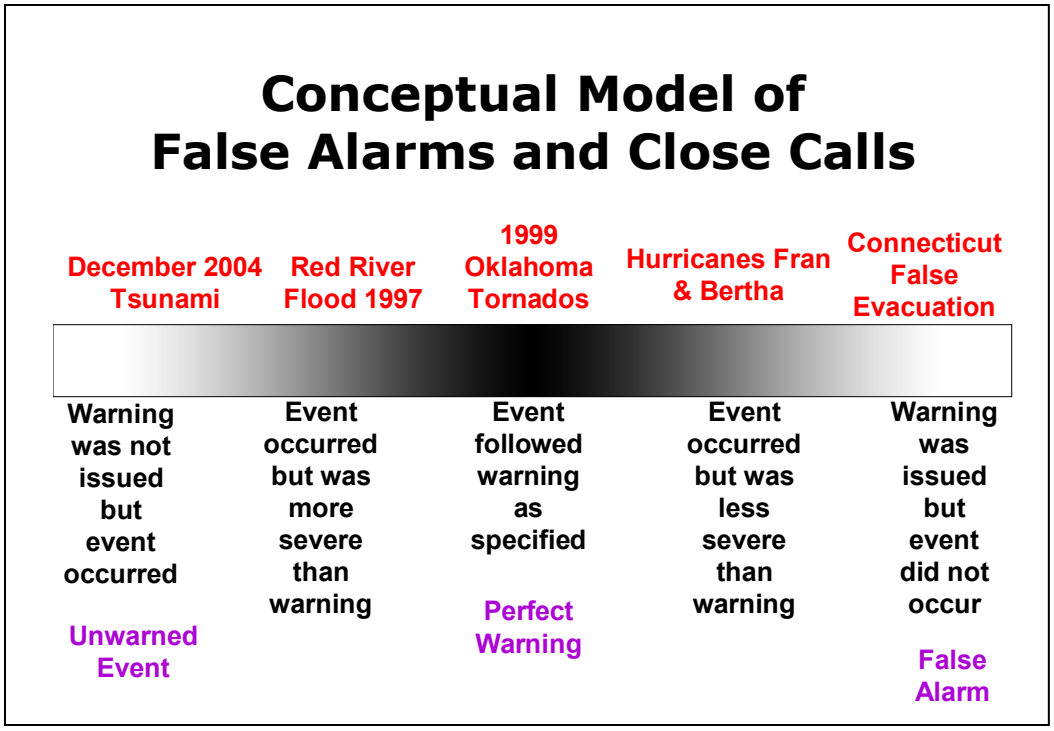
Appendix A.

Hypothesis	Research Effort
Gender:	
Females are more likely to believe warning messages.	Mack & Baker, 1961; Drabek 1969
Females have a higher level of risk perception.	Cutter et al., 1992; Fitzpatrick & Mileti, 1994; Flynn et al., 1994; Alway et al., 1998; O'Brien & Atchison, 1998; Enarson & Scanlon, 1999
Gender and ethnicity affect risk perception.	Hodge et al., 1979
Females are more likely to take protective actions and evacuate.	Enarson & Scanlon, 1991; Major, 1999; Sorensen 2000, Drabek, 1983
Female gender is correlated with hazard adjustments.	Mileti & O'Brien, 1992
Age:	
Older people are less likely than people in other age groups to receive warnings.	Friedsam, 1962
Older people are less likely than people in other age groups to believe warnings.	Friedsam, 1962
Older people are not any less likely than people in other age groups to take protective actions.	Drabek & Boggs, 1968; Drabek, 1983
Older individuals are less likely to be engaged in community participation and kin and friendship networks. These are important factors could result in fewer warnings from peers.	Perry et al., 1981; Perry, 1985
Older people are less likely than people in other age groups to evacuate.	Friedsam, 1962; Mileti et al., 1975; Gruntfest 1977
Older people are more likely than people in other age groups to die or experience serious outcomes in a disaster.	Friedsam, 1962
Older people are more likely than people in other age groups to experience monetary loss in a disaster.	Bolin & Klenow, 1983

Modified from Gruntfest, 1977; Sorensen, 2000

Appendix B.


Conceptual Model of
False Alarms and Close Calls
December 2004 Tsunami
Red River Flood 1997
1999 Oklahoma Tornados
Hurricanes Fran & Bertha
Connecticut False Evacuation
Warning was not issued but event occurred
Unwarned Event
Event occurred but was more severe than warning
Event followed warning as specified
Perfect Warning
Event occurred but was less severe than warning
Warning was issued but event did not occur
False Alarm