CHAPTER 29

Communicating Risk and Uncertainty: Science, Technology, and Disasters at the Crossroads[1]

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It is estimated that about 80% of all disasters are directly tied to weather events; thus forecasting weather has become a very important scientific, economic, and political endeavor. With the development of new and enhanced technology, weather forecasting skills have improved significantly both in the United States and internationally (National Research Council [NRC], 1999, 2003). However, weather forecasting is a probabilistic science and many uncertainties still remain (see National Science Foundation [NSF], 2002). Indeed, despite significant improvements in our ability to predict the weather in the short and long-term, recent experiences with natural hazards show that we continue to confront important challenges regarding lead times, false alarm rates, the accuracy and reliability of the information that is being communicated, and in our ability to elicit the appropriate response from the local, state, and federal governments as well as the general public, as the case of Hurricane Katrina (2005) clearly demonstrated.

We argue that with continued improvements in weather monitoring, detection, and mass communication technology, the social and organizational features of integrated warning systems become paramount as key factors in saving lives and reducing damages to property. Therefore, there is a need to continue to expand our knowledge regarding how individuals, communities, and organizations perceive and react to weather forecasts and warnings. This knowledge must be integrated with other technical information on weather forecasts already available so as to make weather information more useful to society (NRC, 1999).

This chapter explores the role of science, technology, and the media in the communication of warnings, risk, and disaster information. We also focus on how researchers can communicate

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the importance, value, and contributions of hazard and disaster research to the end-user community, including emergency management organizations and the general public. Further, we provide a critical analysis on the importance and potential contributions of interdisciplinary research in the disaster field. We emphasize the need to develop an integrated model to communicate risk and warnings, which takes into account new and emerging technologies, the role of the media, and the changing socioeconomic and demographic characteristics of the general population. Because of space limitations, these issues are discussed primarily in the context of the United States (for an extensive and quite comprehensive bibliography on communicating risk and warnings to the public, both at the national and international level, see Bandy, Johnson Peek, & Sutton, 2004).

The Partnership for Public Warning (2003, p. i) indicates that "public warning empowers people at risk to take actions to reduce losses from natural hazards, accidents and acts of terrorism . . . [it] save lives, reduces fear, and speeds recovery." They also argue that the success of public warnings is measured "by the actions people take." Moreover, the NRC's Panel on the Human Dimensions of Seasonal-to-Interannual Climate Variability points out that the eventual value of improved weather forecasts "will depend on how people and organizations deal with the new kind of information. Are they likely to pay attention to it? Will they understand what the climate models mean for them? Will they trust the messengers?" (1999, p. 16). Even if the public understands weather forecasts, their trust in the reliability and accuracy of these forecasts and in the sources that provide such information may significantly impact their behavior and response (Lindell & Perry, 2004; Mileti, 1999; NRC, 2003; Perry & Greene, 1982). For example, public confidence and trust in the sources that provide such information (e.g., weather forecasts and warnings) has an impact on their perception of risk (Slovic, 1993; Slovic, Flynn, & Layman, 1991). Slovic (2000, p. 410) points out that "the limited effectiveness of risk-communication efforts can be attributed to the lack of trust . . . if trust is lacking, no form or process of communication will be satisfactory." However, trust in institutions is a function of many factors among which minority status and power are readily identifiable (Pérez-Lugo, 2001; Perry & Greene, 1982). Furthermore, mass media accounts conveying inaccurate, biased or sensationalistic information may easily undermine that trust (Fischer, 1994; Nigg, 1987; Quarantelli, 1987b; Pérez-Lugo, 2001; Wenger, Dyke, Sebok, & Neff, 1980).

In order for weather forecasts and warnings to be useful to individuals and communities, they must be understood, must meet their needs, and must provide accurate and reliable information as well as sufficient lead time to allow them to take appropriate action. In this context, up-to-date, continuous, and reliable communication is essential. Previous research has shown that one of the most significant problems with weather forecasts is how the information is presented and communicated to end-user communities (e.g., government agencies, emergency management organizations, industry, and to the general population; see Fischer, 1994; Mileti, 1999; NRC, 1999, 2003). It is noteworthy, however, that even forecasts of severe weather events that attempt to solve these problems may fail to elicit appropriate protective action given that an individual's response to forecasts and warnings is often influenced by factors that have little to do with the technical features of weather forecasts, such as the individual's social class, education, gender, race, ethnicity, cultural background, and previous experiences with weather events.

Access to weather forecasts and warnings, the type of technologies used to access weather information and perceptions (e.g., trust, confidence, and usefulness) regarding weather forecasts and warnings also vary according to race/ethnicity, levels of education, and income (Perry & Greene, 1982; NRC, 1999; Slovic, 2000; Weber & Hsee, 1998). Weather forecast information delivery systems are primarily oriented "to the educated, the affluent, the cultural majority, and the people in power . . . and they are . . . least effective in reaching the elderly, cultural minority groups, people with low incomes, and those without power" (NRC, 1999, p. 86) (For an extensive discussion on the intersection of race/ethnicity, social class and disasters, see the chapter by Bolin in this handbook). Further, although the perception of personal risk is a function of individuals' previous experiences with a given weather hazard, their views about the certainty of its impact, how close they are to it, and how severe they think the impact is likely to be (see Blanchard-Boehm, 1998), there also appears to be a relationship between perceived risk and ethnicity, although this evidence is contradictory. On the one hand, Perry and Greene (1982) suggest that minorities, when compared to majority individuals, have, on average, lower levels of perceived personal risk. On the other hand, more recent research (Slovic, 2000) shows that people of color (and women) are more likely to report a higher degree of perceived health risks to a number of hazards and activities relative to their white counterparts. Slovic points out that women and non-white men "see the world as more dangerous because in many ways they are more vulnerable . . . they benefit less from many of its technologies and institutions, and . . . they have less power and control over what happens in their communities and their lives" (2000, p. 402).

We should also note that although a hazard event can be devastating for a particular society or for a particular group of individuals, its effects are mediated by cultural, social, demographic, economic, and political factors. Some of these factors can ameliorate or exacerbate the effects of a hazard. Furthermore, political and public policy choices, such as whether or not to strengthen and enforce land-use and building codes, will work either to mitigate or exacerbate the hazards' effects, depending on the actual set of choices made. The decision by the United States federal government to not adequately fund improvements in the New Orleans levee system is a particularly striking example of the consequences of inadequate policy making (see U.S. Army Corps of Engineers, 2005). However, it is equally important to note that strategies that individuals, groups, and communities develop to deal with stressful events may result in increased resilience and, therefore, will work in the direction of reducing the hazard's negative consequences. The primacy of these social factors led Quarantelli (2005a) to contend that hazard events (e.g., earthquakes, tornadoes, floods, tsunamis, terrorist attacks, etc.) may result in disasters, not because of the event itself but because of the activities and actions taken (or not taken) at the governmental, community, and individual level.

COMMUNICATING RISK AND WARNINGS

An extraordinary amount of federal and state funding has been allocated to the advancement of science and technology. Financial support to improve weather forecasts, enhance prediction of hazard-related events, and increase lead times has been an institutional practice of governments at different levels. The prevailing assumption behind this spending is that reducing the levels of error or uncertainty in determining if, when, and where an extreme event, such as a tornado, will strike will lead to a reduction in the number of deaths or injuries and property damage as a consequence of improved sensing and prediction. However, this is not necessarily the case.

Although significant improvements in tornado warning systems have been alluded to as one of the important variables in the reduction of tornado-related deaths (see Balluz, Schieve, Holmes, Kiezak, & Malilay, 2000; Mileti, 1999), the research literature also suggests that inadequate warnings and warning systems are one of the primary factors contributing to the number of deaths and injuries caused by hazard events such as tornadoes (see Balluz et al., 2000). Therefore, improving weather forecasts and increasing lead times is only part of the equation in determining the population's preparedness and response to natural hazards.

Moreover, effective and reliable warning systems are only one component that may impact how individuals or communities prepare and respond to such warnings.

Communication is an extremely important component in contributing to or in averting a disaster situation. As Lindell and Perry point out, "one important function of risk communication is, explicitly or implicitly, to promote appropriate protective behavior by those to whom the information is directed" (2004, p. 3). The primary goal of communicating this information to the general population or to a particular community is to protect those who are at risk of being impacted by an impending hazard, with the aim of reducing the loss of life and the number of injuries. Researchers have argued that a disaster is a result of a crisis in the communication process or a result of a communication breakdown (see Gilbert, 1998). This process is commonly said to consist of the following stages: hearing, understanding, believing, confirming, and responding to the hazard warning (see Blanchard-Boehm, 1997; Mileti & Sorenson, 1990). Clearly, any breakdown in the process will most likely result in delayed or incorrect responses to the hazard warning (Blanchard-Boehm, 1998; Lindell & Perry, 2004; Mileti, 1999).

However, human behavior depends on a multitude of demographic, social, cultural, economic, and psychological factors. We know that individuals respond to warnings if they perceive that there is a serious threat to themselves, their families, or their property. Nevertheless, there are a number of other factors that will impact if, how, and when individuals respond to these warnings such as credibility of the information providers, perceived accuracy and reliability of the warning message, the role that the government and affiliated agencies are playing in the warning process, and the content of the messages and the frequency with which the population receives the same (see Blanchard-Boen, 1998; Lindell & Perry, 2004; Mileti & Sorenson, 1990; Nigg, 1995b, to name but a few). Also, the clarity of the message, its consistency, the presence and "respectability" of officials who are providing the warning, the accuracy of past warnings, and the frequency of the hazard will have a significant impact on the credibility of the message and on individual response to the same (Fischer, 1994; Lombardi, 2002; Mileti, 1999). Moreover, adoption of the recommended line of action in severe weather forecasts is a function of many factors including whether potential victims perceive that protection is in fact possible and can be undertaken, which in turn is a function of how much time is available, whether family members are accounted for, and the presence of prior emergency plans. It is also a function of the presence of a belief among those threatened that protective action can significantly reduce the negative consequences of the severe weather event and that the officially recommended actions, in fact, are superior to alternative lines of action taken by kin, neighbors, or advanced by conventional wisdom (Lindell & Perry, 2004; Perry & Greene, 1982).

The adoption of a recommended action also appears to be correlated with race and ethnicity, with the resulting implication that minorities will be less likely to adopt the recommended actions in cases of severe weather events relative to their majority counterparts. This issue is further complicated given that, despite the fact that minorities are more likely to report higher levels of perceived risk (Slovic, 2000), they are less likely to receive the warnings that would allow them to take protective action, and may have limited access to protective resources. For example, preliminary research on response to tornado warnings has shown that African Americans were less likely to report having received warnings when compared to their white counterparts (Paul, Brock, Csiki, & Emerson, 2003; also see Lindell & Perry, 2004). Previous research also shows that minority groups are more likely to be impacted by hazards and disasters, to sustain a greater amount of damage, and to have greater difficulty in recovering from these events relative to their Anglo counterparts (Dash, Peacock, & Morrow, 1997; Peacock & Girard, 1997; Steinberg, 2000). Therefore, having a minority status may be a "risk factor" that contributes to this group's vulnerability to natural hazards and other events (see Cutter et al., 2003).

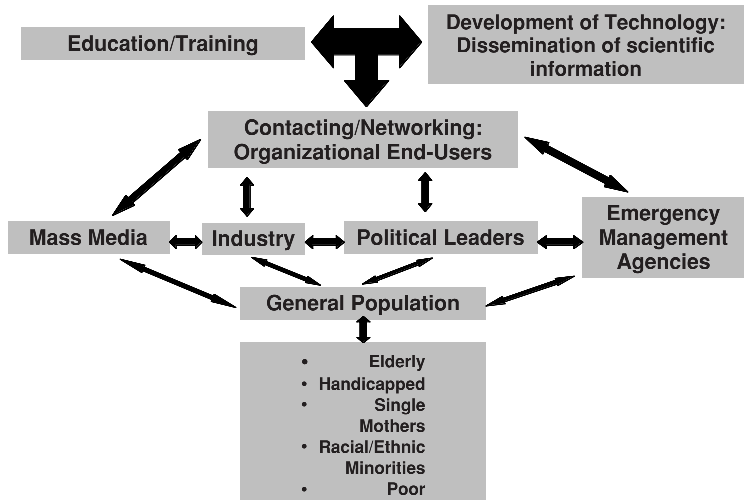

FIGURE 29.1. A model for communicating hazard risk and warnings. This is a modified model based on Nigg's (1995b) Components of an Integrated Warning System.

A MODEL FOR THE COMMUNICATION OF RISK

The above discussion suggests that to generate scientific knowledge, communicate it to the general population in an effective manner, and, therefore, enhance its levels of preparedness and response to a particular hazard, we need to develop an integrated research approach combined with an effective communication model. Figure 29.1 presents a model for communicating hazard risk that accounts for the development of technology, dissemination of scientific knowledge, and education and training of end-users based on Nigg's (1995b) article on the components of a warning system.

The aforementioned model is a result of the integration of scientific knowledge generated by social and physical scientists and engineers regarding hazards and disasters and their impacts on society. This knowledge or scientific information needs to be disseminated to the end-user community using multiple communication sources in a way that is accessible and can be understood by this diverse community. Nevertheless, in order for this information to be useful and to have a significant impact on individual and community response, it must meet the following criteria:

- It must reach the intended end-users or the population at risk in a comprehensible and useful form.
- It must be perceived by them as relevant to their situation (i.e., individuals need to be made aware and recognize the hazard risk and potential outcomes such as the loss of life and damage to property).
- The end-users must have the capacity and the necessary resources to use this information in ways that will allow them to better prepare, respond to, and recover from a hazard or disaster situation.

The model presented in Figure 29.1 is dynamic, multidirectional, and highly dependent on frequent communication and coordination among and between end-user groups (see Nigg, 1995b), through both formal and informal networks. This model also highlights the role and importance of many actors in the risk communication process, including the general public, public officials and government agencies, emergency management personnel, the media, educational institutions and programs, and the private industry. The model reflects the importance of public-private partnerships in the communication of hazard risk. As stated by the Partnership for Public Warning (2005, p. 1), warnings and the communication of this information is a "public responsibility—shared by local, state and federal governments—that relies upon private sector technologies and infrastructure." They further argue that "developing an effective national alert and warning capability requires coordination, cooperation and consensus among the key stakeholders—both public and private."

The communication model in Figure 29.1 also requires the development of multi- or inter-disciplinary research efforts aimed at understanding and disseminating scientific knowledge that will impact society in a useful manner. Disaster losses result from the interaction between physical environments (i.e., hazardous events), the built environment (e.g., infrastructure such as roads, bridges, and buildings), and the social environment (i.e., the social, cultural, demographic, economic, and political characteristics of communities) (see Mileti, 1999). Therefore, to understand the full consequences of hazards and disasters (ranging from communication of risk; risk perception; mitigation and preparedness; behavior and response during an actual event; recovery efforts; and short- and long-term reconstruction strategies) and their societal impact, we have to develop a multi- or interdisciplinary framework.

The interaction between scientists (including engineers and social and physical scientists) and the end-users is indispensable if we are to develop a model that is effective in communicating hazard risk. For example, the NRC's Panel on the Human Dimensions of Seasonal-to-Interannual Climate Variability (1999) points out that the usefulness and utility of climate forecasts can be enhanced by systematically bringing together science and the needs of the end-users. Consequently, end-users will find information that is relevant to their needs, while forecasters can be clear as to what information they need and should provide (NRC, 1999, p. 36). This practice is generally contrary to academic customs in which researchers write for other academics while paying little attention to the needs of practitioners and other end-users (Quarantelli, 1991; Tierney, Lindell, & Perry, 2001). While providing training and education to end-users must be a priority if the proposed communication model is to be successful, researchers must be encouraged to keep in mind the needs of the end-user community. We should also note that public education regarding hazards is an on-going and long-term process that "primes people for response in some future warning" (Mileti, Nathe, Gori, Greene, & Lemersal, 2004, p. 2). Further, this type of hazard education needs to be "people centered" and take into account their socioeconomic and demographic characteristics (for a more detailed discussion on public hazard education, see Mileti et al., 2004).

It is important to highlight that this model (Figure 29.1) includes the general public and communities as integral and active components of the communication process and not as passive bystanders. Researchers, government, and industry must fully comprehend that "warning systems succeed or fail depending on community involvement" (International Strategy for Disaster Reduction [ISDR], 2005, p. 1) thus communities must be active participants in the communication process. We should note that not only do individuals actively participate in this process by seeking to confirm the information that they receive but, just as importantly, by choosing between different and, often, competing sources and technologies to obtain weather, hazard, and disaster information (Lindell & Perry, 2004; Pérez-Lugo, 2001). Further, they will interpret this information according to their unique experiences and perceptions on hazards and disasters. Therefore, attention must be paid to both the needs and preferences for information displayed by different segments of the end-user community and to how the information will be interpreted if we are to effectively communicate with individuals and communities.

THE MASS MEDIA AND THE COMMUNICATION OF RISK AND WARNINGS

There are a variety of sources from which end-users may obtain information regarding hazards and extreme weather conditions or disasters. Among these, the mass media (e.g., television, newspapers, radio, etc.) plays an extremely important role in the communication of hazard and disaster related news and information (King, 2004; Mileti, 1999; Nigg, 1995b; Paul et al., 2003; Pérez-Lugo, 2001; Wijkman & Timberlake, 1988). The media is one of the most important sources of disaster information (Fischer, 1994) and it significantly influences or shapes how the population and the government views, perceives, and responds to hazards and disasters. Dynes (1998, p. 114) even contends that the media define disasters (for a comprehensive overview of the media and disasters, see the chapter by Scanlon in this handbook).

The opinions or views of individuals or groups who are perceived by the general population to be "experts" (in this case the media) play a central or defining role in the construction of risk. As Wildavsky (1979) states, the perception of risk is reflected by the media's coverage of these events. In the context of the United States, Fischer points out that given that Americans rely on the media for disaster information it follows that their beliefs about them will also be a function of the media (1994, p. 23). However, research on the mass media and disasters has often portrayed the media as conveying inaccurate, biased, and exaggerated information, focusing on human loss and physical destruction (Fischer, 1994; King, 2004; Nigg, 1987; Pérez-Lugo, 2001; Quarantelli, 1987b; Wenger et al., 1980). In relation to the negative effects that the media may have on our understanding of hazards and disasters and, therefore, on how we prepare and respond to these events, Mileti (1999) has indicated that the media often convey erroneous information about disasters, thus leading to both decision makers and the general public to draw the wrong conclusions about them. These issues became quite apparent during the aftermath of Hurricane Katrina with widespread rumors, fostered by the mass media, focusing on extensive looting, thousands dead, babies being raped in the Superdome in New Orleans, and criminal activity running rampant; in essence, "a state of chaos and anarchy" (Dynes & Rodriguez, 2005). Of course, it is now apparent that these events were largely exaggerated, based on rumors and incorrect or inaccurate information, sometimes promulgated by elected officials and widely disseminated by the mass media. Nevertheless, the media's portrayal of these events had a significant impact on the public's perception and response to this disaster.

The role and the power of the media in disaster situations are irrefutable. Platt (1999), citing information on what the National Academy of Public Administration has called the "CNN Syndrome," argues that the overwhelming interest of the news media in disasters now means that most disasters are viewed as national or international disasters and, therefore, local responders are thrown into a limelight that may detract from their ability to correctly manage the situation by unnecessarily politicizing it. Platt adds that this may even lead to unnecessary federal disaster declarations.

Further, media coverage does not necessarily focus on the geographic areas or the communities that have been the hardest hit by natural or technological hazards or those that are more vulnerable to these types of events (Steinberg, 2000). Therefore, governmental assistance (e.g., evacuation, shelters, and recovery and reconstruction efforts) may not reach the groups in greatest need but those that receive the greatest news media coverage. It is then logical to assume that the media plays an important role in defining disaster events and may even impact or drive government and community disaster policies and response to such events. On a more positive note, Mileti (1999, p. 225) argues that the news media can potentially play an important and positive role in communicating reliable and accurate information to the general public by disseminating warnings, providing information about affected areas to responders, and giving reassurance to victims.

TECHNOLOGY AND THE COMMUNICATION OF RISK AND WARNINGS

In our discussion, we must also consider the role that the new, or the not so new, and emerging technology has played and continues to play in the dissemination of disaster or hazard-related information and its impact on individual and community behavior and response to disasters. For example, the Internet has become a primary source of weather-related information for a large proportion of the United States population and for the international community as well. Although little is known about the general public's use of weather information (NRC, 1999), The Weather Channel® (2005a, 2005b) claims that 20 million unique individuals access its Internet pages every month and that its cable programming is viewed in 87 million households in the United States alone. AccuWeather™ (2005) claims 4.5 million unique visitors and 60 million page views per month. Further, Adya, Bahl, and Qiu (2002) report that weather forecasts accounted for approximately 500,000 (or 15%) out of 3.25 million notifications sent by a wireless Internet access provider over a 6-day period in August 2000. Other research confirms the primacy of weather as an Internet interest. The Pew Research Center for the People and the Press (2002) reported that, in 1998, with 41% of U.S. adults using the Internet, weather information was the "most popular online news attraction," given that 64% of Internet news consumers sought out weather information.

Practically all, if not all, major news organizations, the National Hurricane Center, the National Weather Service, and the Federal Emergency Management Agency (FEMA), among others, provide continuous and up-to-date weather or disaster information on the Internet and the evidence shows that an increasing number of individuals are accessing the Internet to obtain weather related information. Technological innovations, including weather radar and satellites, geographic information systems (GIS), global positioning systems (GPS), remote sensing, the Internet, wireless connections, e-mail, the development of cellular phones resulting in extensive communication and information networks, text messaging, personal digital assistants (PDAs) and other handheld electronic devices, and fax machines, among others, have transformed the way we communicate and consume weather and disaster information.

Adya et al. (2002) indicate, for example, that access to the Internet through wireless hand-held devices is gaining popularity. In a sample of 72 emergency managers in the State of Oklahoma, Rodríguez, Díaz, and Donner (2005) found that the primary sources used to access weather information by this group of respondents were: the Internet (93%), television (88%), radio (64%), cell phones (28%), and palm pilots and other handheld technology (7%), among others (respondents were allowed to choose all the sources from which they obtained weather-related information). This technology has radically altered the way we collect, process, analyze, utilize, and disseminate information. The media and the ever expanding communication networks have transformed hazards and disasters from local to national and even international events. At least one observer, Mileti (1999, p. 241), argues that these technological developments hold promise for sustainable hazard mitigation efforts because they improve the dissemination of information and reduce the gap between researchers and practitioners. Furthermore, the ascendancy of the Internet reinforces the view of end-users as active players in the communication process, as individuals generally cannot passively receive information through the Internet, rather they must actively seek it out.

Although the general population has greater access to weather information (including severe weather forecasts and warnings) from which to choose, and multiple channels through which they may obtain it, this can also generate problems for consumers of said information. This situation arises if they are receiving information from multiple sources that is inconsistent, contradictory, or incorrect, thus creating confusion and diminishing both its credibility and the population's trust in the sources of weather information and the information that they provide. This, in turn, may have a detrimental impact on individual behavior and response to warnings and to other types of weather-related announcements and messages (for a particularly compelling discussion of these issues in Puerto Rico, see Pérez-Lugo, 2001). Moreover, despite all the technological innovations in the communication field, there are still communities (primarily poor, rural, and minority communities) that do not receive warning messages (see King, 2004; Paul et al., 2003) because they do not have access to the necessary resources (including adequate technology), technological failures or malfunctions, and their lack of visibility to public officials and the mass media, among others. Nevertheless, given the important transformations in telecommunications and information systems and the potential advantages and problems that they may generate, it is time that we rethink and re-conceptualize warning systems and their impact on organizational and individual disaster preparedness and response in such a manner as to explicitly incorporate all of these factors into both our theoretical models and into the real world warning systems that follow from them.

Further, there are a variety of issues that emerge with the creation and development of new technologies. What is the intended use and applicability of emerging technology? What are the major advantages and disadvantages of such systems, particularly as they relate to extreme weather forecasts, warnings, and disasters? Who has the necessary resources to access such technology? How effective, accurate, and reliable is this technology in providing or communicating weather related information and emergency warnings? What type of education and/or training has been provided to end-users to enhance their use and management of the new technology and thus minimize errors and the dissemination of inaccurate or incorrect information to the general public? How has this technology increased our resilience as well as our vulnerability to natural or human-induced hazards?

We must also ask ourselves, how effective is this communication technology at responding to different types of hazards? Different hazards have somewhat different characteristics that are known to impact warning systems. Some events (e.g., hurricanes) are slow-onset hazards that can be followed for an extended period of time, allowing emergency management organizations and the population to track the same and initiate preparedness and response strategies. Tornadoes, on the other hand, are quick-onset events providing very little lead time, so that warnings may be issued only minutes before they strike. Our ability to develop technology and warning systems that take into account these climatological differences and effectively communicate information to emergency management agencies and the general population in an expedient manner is extremely important.

Increasingly, emergency management organizations are developing communication strategies aimed at automatically informing their constituents of impending emergencies. Just recently (October 2005), the Delaware Emergency Management Agency (DEMA) began testing a new emergency warning or alert system for the state, the Delaware Emergency Notification

System (DENS). This system would be able to send out about 3000 calls every 10 minutes to homes and business to provide a warning of an impending emergency. DEMA will be able to activate this system for localized or statewide emergencies and will provide information to the corresponding communities. It is expected that everyone who has a listed telephone number will have immediate access and will be informed of an impending emergency. Individuals or businesses with unlisted numbers will have to register for the service. It is also noteworthy that the State of Oklahoma (among other states) has developed or is currently developing similar warning systems, called "reverse 911."

Despite the spread of such "warning" systems, there are, however, a variety of questions that merit our attention. For example, given the high costs of developing and implementing such technology, will all local communities, particularly minority and poor communities, have the necessary resources to implement these emerging systems? Also, for those communities that are implementing the "reverse 911" systems, how will households that do not have telephone services be warned of an impending threat or danger? How will low-income, migrant, or minority groups, which have higher levels of poverty than the general population and may lack access to telephone services, receive these warnings? Ultimately, we need to know whether the new technologies improve information flows throughout the population or if they merely magnify the informational advantages that the "haves" already enjoy over the "have-nots" (Bimber, 2003), therefore, increasing the "digital divide" and accentuating existing inequalities. This is not an inconsequential issue, as we discuss in the following segment.

Data from the October 2003 United States' Current Population Survey (CPS) show that 68% of households in the United States have a computer, that 60% connect to the Internet from home, and that 34% of the population (61% of Internet users) have used the Internet to obtain "news, weather or sports information." However, there are also strong class and race biases in access to and use of the Internet. For example, in the lowest income quintile, only 37% of households report owning a computer and just 27% report connecting to the Internet, while for the second quintile the corresponding figures are 56% and 45%, respectively. However, for the fourth quintile, 88% of households own at least one computer and 84% connect to the Internet, while for the highest quintile the figures are, 95% and 93%, respectively. Further, similar biases are observed with respect to race and access to broadband Internet connections at home. These are critical issues which warrant our immediate attention in order to generate strategies aimed at effectively communicating risk, warnings, and disaster information to the population at large generally and to minority communities specifically (see Figure 29.1).

CONCLUDING REMARKS: NEXT STEPS AND FUTURE RESEARCH CONSIDERATIONS

It is important for us to emphasize that the payoffs of increasing technological sophistication (and improving lead time), for example, may be reaching a point of diminishing returns in which morbidity will not come down and in fact may increase in the absence of socially based programs to educate the public and facilitate their understanding of weather related information. In this context, the end-user community must be able to provide inputs and feedback to the technical or scientific community that generates this type of information. The science community must, therefore, be receptive and must encourage feedback from the user communities. However, these efforts also require the integration of the knowledge and contributions generated by social science into the technological scientific effort.

Risk and disasters are socially constructed phenomenon, which are influenced by social and cultural norms, prejudices, and values. Therefore, warnings, hazards, and disasters must be studied and understood within the societal context in which they occur. If we continue to emphasize the study and development of technology, while ignoring the social forces that shape individual and community behavior and response to hazards generally and warnings specifically, then we may have "improved" technology without understanding the complexities of human dynamics. Leading researchers in the disaster field have argued that improving local management and decision-making processes will be more critical or important than the majority of future technological innovations (Mileti, 1999, p. 7). Nevertheless, we argue that we should continue to promote the development of new technology but we also need to focus on the social forces that shape organizational, community, and individual behavior and response to hazards generally and warnings specifically. As indicated by Slovic (2000), in his analysis of risk and risk perception, these issues go beyond science and are "deeply rooted in the social and political fabric of our society" (2000, p. 402).

More accurate and reliable weather forecasts and warning systems may lead to improved disaster mitigation, preparedness, and response initiatives. However, improving weather forecasts and increasing lead times is only part of the equation in determining the ultimate effectiveness of organizational and individual preparedness and response to hazards, for it may be that continued increases in lead time of severe weather warnings may fail to protect people given that the associated warning and communication systems do not address the problems of subjectivity and the diverse socioeconomic, cultural, and political factors that may impact human behavior and response to severe weather events and other types of hazards and disasters, as shown by the aftermath of the 2004 Indian Ocean Tsunami (see Rodriguez et al., 2005) and, more recently, Hurricane Katrina. If we are able to link the knowledge and expertise of the social sciences with the technology and other scientific developments generated by engineers and other scientists and communicate the same in an effective manner to the private and public sectors, as well as to the general public, then we will contribute to the growth and development of disaster research and the corresponding communication process.

We must emphasize, however, that although improved communication processes are needed, significant changes also need to occur in the existing scientific paradigms in order to incorporate the needs and problems that the end-user communities confront. Scientists, particularly those focusing on the development of new technology (but not excluding social scientists), must realize that the needs of the end-user communities must be taken into account and integrated, from the very beginning, into the scientific and technical process, including the design and development of warning and communication systems.

As discussed in this chapter, we must reiterate that to develop effective risk communication models, the demographic, social, economic, and cultural characteristics of the population must be taken into account. Who is our audience? What are their characteristics? From what sources do they obtain disaster or weather-related information? Do they have access to the major or most important media outlets that provide information on hazards, disasters, and warnings? What media outlets do they access most frequently? Do they perceive that the media provides accurate, reliable, and up-to-date information? These are important questions that need to be addressed in order to obtain a better understanding of disaster warnings, the mass media, and the population's perceptions and their preparedness and response to disasters. Moreover, the communication process and related models must be modified and adapted to reflect the changing socioeconomic, demographic, and cultural characteristics of the population. For example, the United States is characterized by a growing elderly population. Consequently, the proportion of the population with chronic illnesses and disabilities (e.g., cancer, cardiovascular diseases, and diabetes) will continue to increase. Even if we incorrectly assume that this population has widespread access to the mass media and warnings, will they be able to respond to warning messages or a disaster situation without the assistance of family or community members or from emergency management organizations? These factors must be taken into account in the development of organizational emergency and disaster planning and management policies and in the communication process.

The United States has also experienced a significant increase in the number of female-headed households. These households have lower levels of education and economic resources and thus have higher levels of poverty relative to their male counterparts. Consequently, important issues and problems during a disaster event will emerge for this important sub-group of the U.S. population. Although important research focusing on gender and disasters has been conducted (see Enarson & Meyreles, 2004; Enarson & Morrow, 1998b; Morrow & Enarson, 1996; Peacock, Morrow, & Gladwin, 1997), it is still a slowly emerging subfield that merits the attention of the disaster research community (for a more extensive discussion on this issue, see the chapter by Enarson, Fothergill, and Peek in this handbook).

In a detailed historical analysis of "natural" disasters in America, Steinberg (2000) argues that racial and ethnic minorities (particularly African Americans) have been disproportionately impacted by these events (also see Peacock & Girard, 1997). He further argues, however, that the impact of disasters on these groups has been largely ignored and neglected, adding that "race has had a filtering effect on the collective memory of disaster" (2000, p. 79). In this particular context, it is important to note that, for the most part, disaster researchers have excluded or have "failed to measure" ethnicity in their research (Lindell & Perry, 2004, p. 163; see also the chapter by Bolin in this handbook). To compound matters, in the United States, the minority population has continued to increase and the Latino/a population has become the largest minority group on the mainland; the migration flows from Latin America and Asia will continue to be an important component of population growth for the United States. We also know that, generally, these immigrant groups tend to be at an economic disadvantage when compared to the general U.S. population, experiencing higher levels of unemployment and poverty.

The somewhat limited disaster research literature, which makes reference to racial and ethnic minorities, shows that these groups experience higher levels of vulnerability to natural hazards (Curson, 1989; Dash et al., 1997; Peacock & Girard, 1997). As Curson points out "the poor, the disadvantaged and the marginal generally suffer most, whether the disaster is an epidemic, famine, earthquake, flood or war" (1989, p. 10; also see Wisner, Cannon, Davis, & Blaikie, 2004). These groups are more likely to be minorities, to reside in hazard-prone areas and, given their limited economic resources, will have greater difficulties in recovering from disasters. The aftermath of Hurricane Katrina is a grim reminder of the devastating impacts and consequences that disasters can have on predominantly minority communities in the United States.

Preliminary findings, emerging from field research carried out by the Disaster Research Center (DRC) at the University of Delaware during the aftermath of Hurricane Katrina, show the differential impacts of disasters on minority groups; these problems are further exacerbated if these groups are undocumented immigrants in the United States. These preliminary results show how class, race/ethnicity, gender, and immigration status intersect to increase the vulnerability of minority groups to disasters. Further, variations in terms of previous experiences with hazards, personal life experiences, individual skills, education, cultural beliefs, assimilation into the dominant culture, and the period of time residing in the United States, suggests that minority groups experience and respond to disasters in ways that are quite different from the dominant groups, and are more likely to suffer the differential and disproportionate effects of disasters. As reported by Latino/a evacuees in the aftermath of Hurricane Katrina, one of the primary barriers they encountered was their relative lack of access to official warnings regarding this event and their inability to understand what limited information was available to them because of language barriers. Given these critical issues, we must also consider how the culture of minority groups and recent immigrants, including their primary language, social values, and attitudes, among others, which are distinctly different from those traditionally encountered in the United States, impact how they prepare and respond to disasters and how disaster outcomes, consequences, and recovery vary among these groups.

It seems to us that the warning and risk communication models and processes developed about two decades ago need to be reevaluated given the aforementioned demographic and technological changes that have occurred in the United States. Also, theoretical and methodological approaches to the study of disasters need to be reexamined and further developed in order to incorporate these demographic, cultural, and technological transformations that are impacting national and international communities. These changing factors will impact risk communication and disaster preparedness and response for the unforeseeable future. Thus, we must concentrate our research efforts in understanding how to effectively communicate warnings to this population through diverse mechanisms (print or visual media, radio, community and other informal communication networks) that they have access to, in ways that are understood and are culturally relevant, and through sources that are perceived as reliable and trustworthy. This is extremely important, particularly if one of our goals is to generate individual and community disaster preparedness and response behavior that will minimize the loss of life and property among these racially and ethnically diverse communities.

Finally, given the continuous transformation of communication systems and other technological innovations and processes, these must be further studied to determine their effectiveness in transmitting warning messages and disaster-related information. Extensive research initiatives are also needed focusing on who has access to these new and evolving technologies; how individuals and communities access weather and disaster information; how these systems are used to disseminate information or communicate emergency warnings; and their impact on disaster preparedness and response at the individual, community, and national level.