

# HAZARD WARNING SYSTEMS: REVIEW OF 20 YEARS OF PROGRESS

By John H. Sorensen<sup>1</sup>

**ABSTRACT:** The United States has no comprehensive national warning strategy that covers all hazards in all places. Instead, public warning practices are decentralized across different governments and the private sector. Uneven preparedness to issue warnings exists across local communities; hence, people are unevenly protected from the surprise onset of natural disasters. Without changes in this situation, inequalities will grow larger, and the gains made in saving lives over the past decades may well be reversed. Since the first assessment of research on natural hazards was completed in 1975, there have been significant improvements in forecasts and warnings for some hazards but only marginal improvements for others. Forecasts for floods, hurricanes, and volcanic eruptions have improved most significantly, and public dissemination of warnings has improved the most for hurricanes. However, a 100% reliable warning system does not exist for any hazard.

## INTRODUCTION

Warning systems detect impending disaster, give that information to people at risk, and enable those in danger to make decisions and take action. This definition is simple, but warning systems are complex, because they link many specialties and organizations—science (government and private), engineering, technology, government, news media, and the public. The most effective warning systems integrate the subsystems of detection of extreme events, management of hazard information, and public response. These relationships are maintained through preparedness including planning, exercise, and training. This article summarizes advances in warning-related predictions, forecasts, disseminations, and responses over the past 20 years. It does so by addressing four questions:

- How have prediction and forecasting improved?
- How has warning integration improved?
- How has warning dissemination improved?
- What do we know about response to warnings?

In addition, three major steps to improve warning systems are offered.

## HOW HAVE PREDICTION AND FORECASTING IMPROVED?

Most advances in prediction and forecasting since the nation's first hazard assessment in the 1970s have come from much improved monitoring, instrumentation, data collection, and data processing. Some of these have resulted from advances in theories and models, but no radical theoretical breakthroughs have occurred in the past 20 years. The ability to deliver warnings to the public—

<sup>1</sup>Dir., Emergency Mgmt. Ctr., Oak Ridge Nat. Lab., Bethel Valley Rd., Oak Ridge, TN 37831-6206.

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which means a thorough integration of the scientific component with an effective delivery mechanism—has a checkered record. Table 1 estimates the relative improvement in prediction/forecast and warning integration over the past 20 years [see Mileti (1999) for a discussion of improvements for each hazard in Table 1]. Even given the natural uncertainty in the behavior of hurricanes, improvements in prediction and forecasting capabilities and the ability to graphically present scientific information and warnings for that hazard have been exemplary. This is the case for nuclear power as well, although the impetus for that improvement came from regulatory requirements. Some advances have been made in predicting, detecting, and forecasting floods, tornadoes, volcanoes, landslides, and chemical accidents, but these improvements have yet to be fully integrated into warning dissemination systems. Earthquakes represent a unique case: while dramatic improvements have been made in integrating the warning process, our ability to predict earthquakes has not improved. Finally, four hazards have shown little change in either prediction/forecast or warning integration: droughts, wildfires, snow avalanches, and tsunamis.

## HOW HAS WARNING INTEGRATION IMPROVED?

Although warning integration has not been improved for all hazards, our ability to issue timely warnings for

**TABLE 1. Improvements in Prediction, Forecast, and Warning Integration**

Hazard (1)	Prediction/forecast (2)	Warning integration (3)
Flood	Some improvement	Not much improvement
Hurricane	Major improvements	Major improvements
Tornado	Some improvement	Not much improvement
Drought	Not much improvement	Not much improvement
Fire	Not much improvement	Not much improvement
Avalanche	Not much improvement	Not much improvement
Earthquake	Not much improvement	Major improvements
Volcano	Some improvement	Not much improvement
Tsunami	Not much improvement	Not much improvement
Landslide	Some improvement	Not much improvement
Nuclear power	Major improvements	Major improvements
Hazardous materials/chemicals	Major improvements	Not much improvement

hazards in general continues to improve. This is attributable to a considerable amount of knowledge that has been developed on how to build an effective warning system. A key overriding principle that has continued to emerge from 25 years of warning research is that an integrated warning system maximizes public protection. Integration refers to the melding of scientific monitoring and detection with an emergency organization that utilizes warning technologies coupled with social design factors to rapidly issue an alert and notification to the public at risk. Thus, warning systems must be considered as having scientific, managerial, technological, and social components that are linked by a variety of communication processes. A breakdown in the process can result in an ineffective warning, even if each individual component is properly performing its internal role, such as monitoring a volcano or making a decision that a threat to the public exists.

### **Warning Technologies**

In the past 20 years, major advances have been made in warning system technology. The most common technologies used for public warnings are outdoor sirens, the electronic media, and officials going through the streets with loudspeakers (route alert). The major limitations of sirens were that people did not pay much attention to them and did not understand the meaning of different sounding signals. Now, electronic sirens with voice capabilities provide an alert mechanism as well as a voice message. The major limit of the electronic media in reaching the public with a warning message is that their effectiveness is highly variable depending on the time of day. Route alert is constrained by the number of emergency personnel available to disseminate the warning versus the size of the area to be warned.

Other technologies also exist. Tone alert radio (TAR) technology provides a highly personalized warning mechanism. The National Weather Service has used this technology for some time. Recent advances in battery design, self-diagnostic circuitry, and human factors engineering make TAR technology a very reliable method of disseminating warnings.

In 1994, the Federal Communications Commission announced they would replace the Emergency Broadcast System with the Emergency Alert System (EAS). The EAS is designed to take advantage of current digital communications technology. All commercial broadcast stations and cable companies will be required to participate in the system, which was implemented in January 1997. Some of the features of this new system are multiple alerting sources, remote operations, and targeting of specific geographical areas using specific area message encoder capabilities. EAS technology involves use of a standardized code that controls the functioning of the system. For example, the code can be set to interrupt normal programming for certain conditions and to choose the appropriate prerecorded audio and visual materials to be broadcast. The broadcast materials can be matched to the originator

of the message, the event, and the location. Messages can be developed in multiple languages and sent out by the media channel appropriate for each foreign language speaking population. In addition, special radios, televisions, computers, and other electronic devices will be marketed that have remote activation capabilities. Eventually, EAS will replace the current TAR technology.

Telephones are obvious communication devices but have been limited in their emergency warning use. Computer technologies enabling rapid sequential auto dialing and switching equipment enabling simultaneous dialing have made the household phone part of an advanced rapid warning system. Computer controls of warning systems have enabled more specific targeting of warning delivery and increased system reliability by enabling silent testing. Little is known about the effectiveness of these systems.

A variety of technologies such as teletypewriters, telephone devices for the deaf, and voice carry over, and even strobe lights have enabled warning systems for people with hearing impairments. Overall, technology improvements have increased the potential speed of warning dissemination and provided greater system reliability. In the next decade, pagers will likely become an important public warning technology.

### **Warning System Type**

One important general finding is that a single warning concept will not equally serve the requirements of all hazards (Mileti and Sorensen 1990). A system designed for a hurricane will not be good for a flash flood. Likewise, a general alert or warning may not be adequate when a very specific warning is needed. Cases exist where the warning clearly failed because the wrong system design was used or assumed. This is often found when a rare event occurs in a location with a frequently reoccurring event of a different nature (e.g., a tornado occurs in an area of frequent hurricanes). Thus an all-hazard warning system is inappropriate unless the specific needs imposed by each different hazard type are also considered.

### **Protective Actions**

The most common recommendation for a protective action in a warning is to evacuate. Research, however, continues to document cases where evacuation is not the best action. A major cause of fatalities in flash floods is attempted evacuation in a vehicle. As a result, planning should consider an extended range of alternatives such as vertical evacuation for floods and hurricanes and in-place sheltering for tornadoes and earthquakes. Very little research has been conducted on the response of warnings to seek shelter (Liu et al. 1996)

### **Establishing Planning Basis**

A number of questions face the emergency manager when issuing a public warning: How many people will respond? How fast will they act? What will they do?

Where will they go? Will people go to an official shelter? How many vehicles will a family take? Will they bring adequate supplies? Will they bring a pet? (and other related questions of interest). In the absence of direct community experience, planners have used behavioral intent surveys to address these questions. The work of Nelson et al. (1989) with Hurricane Elena provides the first good empirical evidence that behavioral intent surveys do not accurately predict warning response. Social science knowledge on what influences variations in response and actual behavioral data provide a better planning basis than that provided by data collected from "what if" type surveys.

### **Shelter Use**

Behavioral survey data have been used for predicting the level of shelter use (Mileti et al. 1992). Empirical research and theory development suggest mass care shelter use by evacuees in the United States averages about 15% of the evacuated population. Use generally increases in areas with an older population of low socioeconomic status and decreases with younger more affluent populations.

### **Institutional Populations**

Institutional populations include schools, hospitals, prisons, nursing homes, and other facilities with a client population. The first systematic study of the response of institutions to warnings was conducted by Vogt (1990). This study showed that despite little preparedness for events other than fires, institutions were very adaptive at moving their clients and made effective use of volunteers. However, many difficulties were encountered in providing mass care for the clients at the shelter site.

### **Warning Myths**

Many emergency managers in the United States believe in a set of popular myths and perceptions about warnings and public response to warnings. These myths all too often constrain the effectiveness of warning systems when implemented. The most common myth is the public panics in response to warnings of impending disasters. Social scientists have shown this is not the case except in situations where there is closed physical space, an immediate and clear source of death, and where escape routes are available but obviously not accessible to everyone (Quarantelli 1980, 1984). Second, officials are usually worried about overwhelming people with too much information. However, the public rarely, if ever, gets too much emergency information in a warning. Third, officials are concerned with issuing false alarms. The likelihood of people responding to a warning is not diminished by what has come to be labeled the "cry-wolf" syndrome if the basis of the false alarm is understood, although repetitive false alarms may decrease response (Dow and Cutter 1998). Fourth, officials think that a single spokesperson is a good

practice to disseminate emergency information. People at risk who are the targets of emergency warnings need information from a variety of sources, not from one single source. Fifth, officials think that people will take action immediately on the receipt of a warning. Most people simply do not take action in response to warning messages as soon as they hear their first warning. Sixth, officials often think that people will follow recommendations made in a warning. Research shows, however, people will not blindly follow instructions in a warning message, unless the basis for the instruction is given in the message, and that basis makes "common sense."

### **Effective Messages**

A well constructed message prototype for an emergency is important to the quick dissemination of information. The style and content of a message can have a dramatic effect on public response. Sufficient research has been conducted to discern a poor message from a good one and even a good one from one that reflects state-of-the-art practices (Sorensen and Mileti 1989; Vogt and Sorensen 1992). Five specific topics that are important to include in assembling the actual content of a public warning message are the nature, location, guidance, time, and source of the hazard or risk. The style aspects that are important to include are message specificity, consistency, accuracy, certainty, and clarity.

### **Public Education**

There is no conclusive evidence regarding whether or not a public education or information program actually makes a significant difference of increasing human response to warnings. The most reasonable interpretation of the evidence, when considering the empirical, anecdotal, and practical, is that a good preemergency information program will increase response although the amount cannot be estimated. Conversely, a poor program will not likely make a great overall difference.

### **HOW HAS WARNING DISSEMINATION IMPROVED?**

Much progress has been made recently on measuring and modeling warning dissemination and response (Rogers and Sorensen 1989; Sorensen and Mileti 1989; Lindell and Perry 1992). The knowledge generated includes data on

- The time decision makers take in reaching a decision to issue a warning
- The time it takes to disseminate a warning via different technologies and strategies
- The time it takes people to reach a decision to act on a warning
- The time it takes to carry out alternative protective actions such as sheltering or evacuation

Among the general lessons learned from research in this area are the following:

- Officials are often slow in reaching a decision; slow decisions often prevent a timely warning to the public at risk.
- Most populations at risk can be notified in about 3 h or less without specialized warning systems.
- Warnings are more slowly disseminated at night than in evening or daytime hours.
- New warning technologies (such as telephone ring down systems) can achieve very rapid warning.
- Informal notification plays an important role in the warning dissemination in most emergencies.
- The time people spend responding to a warning corresponds to an S-shaped (logistic) curve.
- The time people spend in responding to a warning depends on the perceived urgency of the threat.
- The time required to evacuate a population is unrelated to the size of the population.

Fig. 1 depicts the general dissemination times of alternative communication technologies. Dissemination is based on the number of people initially notified by the warning technology and by the informal notification process. The latter is composed of family, friends, and neighbors contacting others who may not have heard the official warning. Informal notification can account for as much as one-half the initial warning in a disaster. The figure also shows that specialized warning devices are capable of more rapid dissemination of a warning than the media can achieve. In addition, recent work suggests the most effective warning systems have indoor and outdoor alert and notification components.

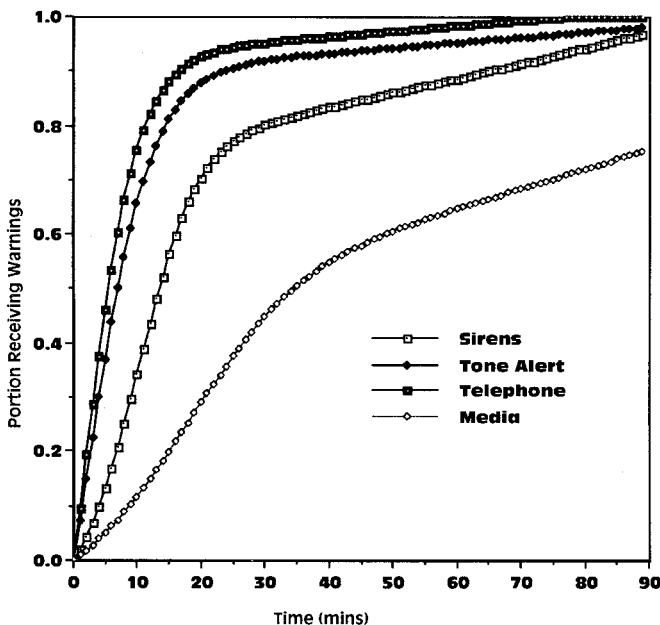


FIG. 1. Average Dissemination Time for Alternative Warning System Technologies (Rogers and Sorensen 1988)

## WHAT DO WE KNOW ABOUT RESPONSE TO WARNINGS?

A significant level of knowledge has been developed on human response to warnings at the individual/family level and at the emergency warning organizational level (Drabek 1986). This is summarized in detail in several recent publications (Lindell and Perry 1992; Mileti and Sorensen 1990). Some of the key concepts and findings from this research are summarized in this paper.

### Emergency Warning Organizations

General principles that facilitate and undermine coordination and effective organizational responses are fairly well defined. Simply stated, coordination seems to be maximized when organizations (1) know what they and other organizations are supposed to do in an emergency; (2) know who is to do it; (3) have designated and understood communication ties to others in the network; and (4) maintain flexibility (Anderson 1969; Dynes 1970; Mileti and Sorensen 1987; Lindell and Perry 1992). Communication problems, due to equipment and human failure, are the most significant causes of poor warning dissemination (Sorensen and Mileti 1987).

### Public Response

A robust understanding of warning compliance has been developed by social science researchers. The focus of their research has been on whether or not people evacuate when advised to do so (Lachman et al. 1961; Withey 1962; Williams 1964; Drabek and Boggs 1968; Drabek 1969, 1983; Drabek and Stephenson 1971; Mileti 1975; Baker 1979; Perry 1979; Quarantelli 1980, 1984; Leik et al. 1981; Perry et al. 1981, 1982; Cutter and Barnes 1982; Perry and Greene 1982, 1983; Perry and Mushkatel 1984, 1986; Stallings 1984; Mileti and Sorensen 1988; Dow and Cutter 1998). In contrast, little work has been conducted on choice of protective action alternatives. Furthermore, little work has been conducted on explaining individual variations in response to warnings such as the timing of response (Sorensen 1992). For example, what differentiates early or rapid responders from those who delay their response?

Warning response involves a sequence of cognitive and behavioral steps. Lindell and Perry (1992) characterize warning response as a four-stage process:

- Risk identification: Does the threat exist?
- Risk assessment: Is protection needed?
- Risk reduction: Is protection feasible?
- Protective response: What action to take?

Mileti and Sorensen (1990) characterize the process as sequential:

- Hearing the warning
- Understanding the contents of the warning message

**TABLE 2. Major Factors Covarying with Warning Response**

Factor (1)	Response due to factor increase (2)	Level of empirical support (3)
Physical cues	Increases	High
Social cues	Increases	High
Perceived risk	Increases	Moderate
Knowledge of hazard	Increases	High
Experience with hazard	Mixed	High
Education	Increases	High
Family planning	Increases	Low
Fatalistic beliefs	Decreases	Low
Resource level	Increases	Moderate
Family united	Increases	High
Family size	Increases	Moderate
Kin relations (number)	Increases	High
Community involvement	Increases	High
Ethnic group member	Decreases	High
Age	Mixed	High
Socioeconomic status	Increases	High
Being female versus male	Increases	Moderate
Having children	Increases	Moderate
Channel: Electronic	Mixed	Low
Media	Mixed	Low
Siren	Decreases	Low
Personal warning versus impersonal	Increases	High
Proximity to threat	Increases	Low
Message specificity	Increases	High
Number of channels	Increases	Low
Frequency	Increases	High
Message consistency	Increases	High
Message certainty	Increases	High
Source credibility	Decreases	High
Fear of looting	Decreases	Moderate
Time to impact	Decreases	Moderate
Source familiarity	Increases	High

- Believing the warning is credible and accurate
- Personalizing the warning to oneself
- Confirming that the warning is true and others are taking heed
- Responding by taking a protective action

Social scientists have identified general and specific factors that affect the warning response process that include sender and receiver factors, situational factors, and social contact. The specific factors are summarized in Table 2 (Mileti and Sorensen 1990). Only a few of these factors can be manipulated as part of the warning process. The primary way a warning response can be affected by the emergency planner is in the design of the warning system including the channel of communication, public education, and specific wording of the emergency message. In addition, incentives can be offered to increase response, including information hotlines, transportation assistance, mass care facilities, and security and property protection (Lindell and Perry 1992).

**WHERE DO WE NEED TO GO IN THE NEXT 20 YEARS?**

There is little doubt that improvements in prediction, forecast, and warnings have dramatically reduced deaths and injuries in the United States since the nation's first

natural hazard assessment (White and Haas 1975). This is true for all hazards, but the same is unfortunately not true for many other parts of the world, particularly lesser-developed nations. Obviously, warnings can save lives and some moveable property and can reduce injuries. Beyond that, short-term (minutes to days) warning systems seem to have little direct bearing on sustainable development; if links do exist, they have not yet been explored. Although they reduce deaths and injuries, warning systems have not been demonstrated to have any significant impact on reducing damage to social infrastructure or private property or on reducing economic disruption. In fact, short-term warning systems may hinder the movement toward sustainability by allowing long-term occupancy of marginal lands. For example, if people can return to occupy areas of high hazard such as a floodplain or a landslide prone coastline because a warning system helped them avoid death or injury, the presence of a warning system may actually increase economic losses in the long run and jeopardize a sustainable economy. Again, the evidence is scanty and warrants further attention.

On the other hand, long-term warning systems (years to decades or longer) may have a major role to play in sustainable hazards mitigation. Long-term forecasts would provide local decision makers with some of the information needed to design their future communities. A certain amount of future losses would be part of any community's sustainable hazards mitigation plan because losses could never be reduced to zero. Long-term forecast systems would help redefine the risks that communities want to reduce, and information about the systems would be vital to the local planning process.

To improve integrated warning systems, three key steps are needed:

- A national warning strategy. The United States does not have a comprehensive national warning strategy. Warning practices are divided over different governmental entities and the private sector. For example, the new EAS being developed by the Federal Communications Commission is coordinated with the National Weather Service but not with other public or private providers of prediction and forecast information or with organizations involved with nonweather related hazards. Moreover, different local communities vary greatly in the quality and likely effectiveness of in-place warning systems. The nation needs to develop a comprehensive model for warning the public, provide it to local communities along with technical assistance, and make the degree of protection provided by warnings systems for all citizens more equitable.
- Improving warning systems. Public alert systems can be improved with new hardware and technology, but diffusing existing technology and warning preparedness knowledge is a much bigger problem in the nation today. Further technological advances will only

increase the gap between practice and the state of the art. An exception would be the development of very inexpensive equipment that could be easily installed and maintained and could rapidly alert and notify the public. The diffusion of specific area message encoder enabled EAS warning devices into American households will likely be a slow process. These devices are now commercially available; however, very few low-income residents will be able to afford them. Furthermore, the EAS cannot provide outdoor warnings.

Improvements to local warning systems are needed on two fronts. The first is the dissemination of information on low-cost or no-cost improvements. This includes improved procedures and management practices, which can result in a much better warning system without major financial expenditures. The second is the provision of resources for a better warning system and related communications equipment. Few communities have the funds to install new equipment and will therefore require technical assistance and/or cost sharing. Better local management and decision making about the warning process are more critical than promoting more advanced technologies, although both would help. The most sophisticated equipment is relatively useless unless it can be used properly.

- Knowledge gaps. The ability of a system to provide timely public warnings begins with monitoring the environment to detect hazards. Detection technology is readily available for some hazards but is only in a state of development for others. Technological capabilities also vary with respect to the amount of lead time provided and the “noise” in the detection signal. Monitoring technologies, which provide ongoing data about the physical system, are of equal importance. Again, monitoring coverage is fairly good for some hazards but poor for others, such as hazardous materials accidents. Complete coverage of the entire U.S. land mass, or even of all populated areas, has not been achieved for any hazard. There is much room for improvement in the next 20 years.

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## APPENDIX. REFERENCES

Anderson, W. (1969). “Disaster warning and communication processes in two communities.” *J. Communication*, 19(June), 92–104.

Baker, E. J. (1979). “Predicting response to hurricane warnings: A reanalysis of data from four studies.” *Mass Emergencies*, 4, 9–24.

Cutter, S., and Barnes, K. (1982). “Evacuation behavior at Three Mile Island.” *Disasters*, 6, 116–124.

Dow, K., and Cutter, S. (1998). “Crying wolf: Repeat responses to hurricane evacuation orders.” *Coast. Mgmt.*, 26, 237–252.

Drabek, T. (1969). “Social processes in disaster: Family evacuation.” *Social Problems*, 16(Winter), 336–349.

Drabek, T. (1983). “Shall we leave? A study of family reactions when disaster strikes.” *Emergency Mgmt. Rev.*, 1(Fall), 25–29.

Drabek, T. (1986). *Human system response to disaster: An inventory of sociological findings*. Springer, New York.

Drabek, T., and Boggs, K. (1968). “Families in disaster: Reactions and relatives.” *J. Marriage and the Family*, 30(August), 443–451.

Drabek, T., and Stephenson, J., III. (1971). “When disaster strikes.” *J. Appl. Social Psychology*, 1(2), 187–203.

Dynes, R. (1970). *Organized behavior in disasters*. D. C. Heath, Lexington, Mass.

Greene, M., Perry, R., and Lindell, M. (1981). “The March 1980 eruptions of Mt. St. Helens: Citizen perceptions of volcano threat.” *Disasters*, 5(1), 49–66.

Gruntfest, E., and Huber, C. (1989). “Status report on flood warning systems in the United States.” *Envir. Mgmt.*, 13(3), 279–286.

Lachman, R., Tatsuoka, M., and Bonk, W. (1961). “Human behavior during the tsunami of May, 1960.” *Sci.*, 133(May 5), 1405–1409.

Leik, R., Carter, T. M., and Clark, J. (1981). “Community response to natural hazard warnings: Final report.” *Rep.*, University of Minnesota, Minneapolis.

Lindell, M., and Perry, R. (1992). *Behavioral foundations of community emergency planning*. Hemisphere Publishing Co., Washington.

Liu, S., Quenemoen, L., Maliday, J., Moji, E., Sinks, T., and Mendlein, J. (1996). “Assessment of a severe-weather warning system and disaster preparedness, Calhoun County, Alabama, 1994.” *Am. J. Public Health*, 86(1), 87–89.

Mileti, D. (1975). *Natural hazard warning systems in the United States*. Institute of Behavioral Science, University of Colorado, Boulder, Colo.

Mileti, D. (1999). *Disasters by design*. The Joseph Henry Press, Washington, D.C.

Mileti, D., and Sorensen, J. (1987). “Determinants of organizational effectiveness in crisis.” *Columbia Univ. J. World Business*, 12(1).

Mileti, D., and Sorensen, J. (1988). “Planning and implementing warning systems.” *Mental health care in mass emergencies: Theory and practice*, Brunner/Mazel Psychological Stress Series, M. Lystad, ed., New York, 321–345.

Mileti, D., and Sorensen, J. (1989). “La eficacia de los sistemas de alarma en America Latina.” *Consecuencias psicosociales de los desastres: La Experiencia Latinoamericana*, B. Lima and M. Gaviria, eds., Centro de la Familia Hispanica, Chicago, 187–198.

Mileti, D., and Sorensen, J. (1990). “Communication of emergency public warnings.” *ORNL-6609*, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Mileti, D., Sorensen, J., and O’Brien, J. (1992). “Towards an explanation of mass care shelter use in evacuations.” *Int. J. Mass Emergencies and Disasters*, 10(1), 25–42.

Nelson, C., Crumley, C., Fritzsche, B., and Adcock, B. (1989). *Lower Southwest Florida hurricane study*. University of South Florida, Tampa, Fla., or U.S. Army Corps of Engineers, Jacksonville, Fla.

Perry, R. (1979). “Evacuation decision-making in natural disasters.” *Mass Emergencies*, 4(March), 25–38.

Perry, R., and Greene, M. (1982). “The role of ethnicity in the emergency decision-making process.” *Sociological Inquiry*, 52(Fall), 309–334.

Perry, R., and Greene, M. (1983). *Citizen response to volcanic eruptions: The case of Mount St. Helens*. Irvington Publishers, Inc., New York.

Perry, R., Lindell, M., and Greene, M. (1981). *Evacuation planning in emergency management*. Lexington Books, Lexington, Mass.

Perry, R., Lindell, M., and Greene, M. (1982). “Threat perception and public response to volcano hazard.” *J. Social Psychology*, 116, 199–204.

Perry, R., and Mushkatel, A. (1984). *Disaster management: Warning response and community relocation*. Quorum Books, Westport, Conn.

Perry, R., and Mushkatel, A. (1986). *Minority citizens in disaster*. University of Georgia Press, Athens, Ga.

- Quarantelli, E. (1980). *Evacuation behavior and problems: Findings and implications from the research literature*. Disaster Res. Ctr., Ohio State University Press, Columbus, Ohio
- Quarantelli, E. (1984). "Perceptions and reactions to emergency warnings of sudden hazards." *Ergonomics*, 309(Nov.–Dec.).
- Rogers, G., and Sorensen, J. (1988). "Diffusion of emergency warnings." *Environ. Probl.*, 10, 281–294.
- Sorensen, J. (1991). "When shall we leave: Factors affecting the timing of evacuation departures." *Int. J. Mass Emergencies and Disasters*, 9(2), 153–165.
- Sorensen, J., and Mileti, D. (1987). "Decision making uncertainties in emergency warning system organizations." *Int. J. Mass Emergencies and Disasters*, 5(1).
- Sorensen, J., and Mileti, D. (1989). "Warning and evacuation: answering some basic questions." *Industrial Crisis Quarterly*, 2(3–4), 195–210.
- Sorensen, J., and Rogers, G. (1988). "Community preparedness for chemical emergencies: A survey of U.S. communities." *Industrial Crisis Quarterly*, 2(2), 89–108.
- Stallings, R. (1984). "Evacuation behavior at Three Mile Island." *Int. J. Mass Emergencies and Disasters*, 2, 11–26.
- Vogt, B. (1990). "Evacuation of institutionalized and specialized populations." *ORNL/SUB-7685/1 and T23*, Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Vogt, B., and Sorensen, J. (1992). "Preparing EBS messages." *ORNL/TM-12163*, Oak Ridge National Laboratory, Oak Ridge, Tenn.
- Williams H. (1964). "Human factors in the warning and response systems." *The threat of impending disaster*, G. Grosser et al., ed., MIT Press, Cambridge, Mass. 79–104.
- Withey, S. (1962). "Reaction to uncertain threat." *Man and society in disaster*, G. Baker and D. Chapman, eds., Basic Books, New York, 93–123.