

CHAPTER 11

Community Processes: Warning and Evacuation

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Almost every day people evacuate from their homes, businesses or other sites, and even ships in response to actual or predicted threats or hazards. Evacuation is the primary protective action utilized in large-scale disasters such as hurricanes, floods, tsunamis, volcanic eruptions, releases of hazardous or nuclear materials, and high-rise building fires and explosions. Although often precautionary, protecting human lives by withdrawing populations during times of threat remains a major emergency management strategy. There have been some instances in which removal of property and livestock to safer places has been a major evacuation activity for some businesses such as automobile or boat dealers or specialty farm managers, but these evacuation activities lack systematic validation. Although there is some excellent research on evacuation behavior in other countries, such as the Holland floods in the early 1950s, the focus of this chapter is on evacuation behavior in the United States.

The term “evacuation” is used to describe the withdrawal actions of persons from a specific area because of a real or anticipated threat or hazard. The time period for the span of withdrawal is elastic in that the evacuation may last for any amount of time, and may occur more than once or sequentially should there be secondary hazards or a reoccurrence or escalation of the original threat. For example, while the primary hazards from hurricanes are wind and storm surge flooding, secondary threats could include inland riverine flooding that might necessitate a second evacuation effort. Further, the evacuation experience can include events when a return to the original site is not feasible or forbidden, as when the federal government buys out or relocates communities prone to recurring floods or when a state or federal agency quarantines a contaminated area. In this sense, the definition of evacuation used here deviates from that of some other researchers, such as Quarantelli (1980a), who have suggested that evacuation be considered a round-trip event. Given such events as Hurricanes Andrew and Katrina, Chernobyl, drought and civil wars in South Africa, and sites made uninhabitable by persistent chemical hazards, the decision to include long-term resettlement or relocation as part of the evacuation continuum appears appropriate. Long-term relocation of populations and the issues associated with extended evacuation periods such as after hurricanes or terrorist events may signal a trend affecting evacuation research agendas in the future.

As an alternative to evacuation, people may take protective shelter inside structures to prevent harm during severe weather that includes lightning, tornados, and hail as well as

exposure to harmful substances in the air, or to quarantine during an infectious outbreak. “Vertical evacuation” in hurricanes in which people move to the upper floor of a modern high-rise building is also a form of sheltering and should not be termed evacuation. In some incidents, officials have advised both sheltering and evacuating either simultaneously for selected groups or sequentially for fast moving hazards. For example, when a toxic chemical cloud is moving rapidly over an area, people may be told to shelter and then evacuate their shelters once the major threat has passed the structure. This is because the build-up of contaminated air inside the structure will likely be higher than that of outside air once the cloud has passed. In comparison to evacuation, sheltering behavior is less understood with only a few social science studies having been conducted in the past 25 years, including Three Mile Island (Cutter & Barnes, 1982) and a hazardous material release from an explosion in Arkansas (Vogt & Sorensen, 1999).

In the last two decades there has been a greater focus on the varieties of subgroups that require special attention, such as assisted care individuals or high-rise building occupants, and on the timing of warnings to alert and notify residents of the potential threat. The attention to occupant evacuation behavior after the 2001 World Trade Center (WTC) disaster has been the most crucial in changing the evacuation and engineering paradigms for high-rise buildings that are likely to be felt worldwide as the findings are disseminated (Natural Hazard Research and Applications Information Center, 2003). These trends have led to better typologies and planning models and more critical attention to factors affecting protective actions in planning and response. Real-time transportation models developed over the past decade also allow transportation engineers to better direct egress routes but the models require more sophisticated computer modeling that many communities, especially the more rural or those with a number of absentee owners, may not have resources to incorporate into their emergency plans.

Although evacuation behavior has been closely associated with officials issuing warnings, people often spontaneously evacuate (evacuate without an official order) or refuse to comply with an evacuation order for a variety of reasons (Lindell & Perry, 2004). Evacuations work best if a community plans, organizes, develops, installs, and maintains a warning system (Lindell & Perry, 1992; Mileti & Sorensen, 1990). Developing the warning system is both an engineering process and an organizational process. Warning systems are more than technology—involving human communication, management, and decision-making. As was solidly demonstrated by the experiences on September 11, 2001, disaster in the WTC high-rise buildings, warning systems also extend far beyond “official systems” as most of the evacuees in WTC 2, the second building to be hit, initiated their evacuation before they were warned to evacuate by the building’s public address system, which occurred 1 minute prior to impact (Averill et al., 2005).

In this chapter we first briefly discuss the social construction of evacuation and the changing social and technological context of evacuation. Next we examine the extent of systematic studies conducted by disaster researchers on warnings that lead to protective actions. Four major research themes are then examined:

- warning and warning response,
- societal characteristics,
- organizational response, and
- behavior in evacuations.

EVACUATION AS A COMMUNITY PROCESS

Although evacuations occur daily in the United States, it is difficult to typify a generic model because evacuations lack both definition and consensus on specific parameters. Drabek and Stephenson (1971) defined four types of evacuation: by invitation, choice, default,

or compromise. Evacuation by invitation occurs when someone outside the area at risk provides the means or impetus to leave. Evacuation by decision or choice involves individuals processing warning information, deciding to leave, and then taking action. Evacuation by default involves behavior dictated by actions other than seeking safety from the hazard (such as not being allowed by officials to enter an evacuated zone or structure upon one's return). Evacuation by compromise is characterized by people following orders even though they do not want to or feel it necessary to leave (Sorensen, Vogt, & Mileti, 1987). By cross-classifying two dimensions of evacuations—timing and period of evacuation—Perry, Lindell, and Greene (1981) distinguished four types of evacuations: preventative (pre-impact, short-term), protective (pre-impact, long-term), rescue (post-impact, short-term), and reconstructive (post-impact, long-term).

Occurring across various time periods and affecting various numbers of people or groups, evacuations can also impose significant psychological and physical impacts on those involved or who are close to evacuees. Evidence from the 2004 hurricanes in Florida suggests that those impacts may be delayed as well as have effects at significant distances from the hazard source. For example, after the 2004 hurricanes many low-income elderly evacuees found it impossible to rebuild their damaged residences and as a result were forced to move to other states to live with family members. Evacuees from Floyd traveled to destinations across several counties and even into other states seeking refuge (Hazards Management Group, no date). Public outcry over congested highways used for evacuation routes for Hurricane Floyd also forced states to consider coordinating with other state's departments of transportation on traffic planning (Wolshon et al., 2005).

Evacuation is rarely an individual process. Even in single-person households, the first response to the initial evacuation warning is to seek further information on the validity of the threat or to consult with a friend, co-worker, neighbor, family member, or relative. Evacuations usually take place in a group context (Drabek & Stephenson, 1971). Families will try to reunite, if possible, to evacuate as a group, but not necessarily in a single vehicle if two or more vehicles are owned. In business settings, co-workers typically evacuate in groups (Aguirre, Wenger, & Vigo, 1998), and may be expected to regroup once evacuated.

Events that necessitate evacuation vary widely from natural or technological disasters to deliberate terrorist events. Aside from the fundamental issue of intent in terrorist-induced disasters, there are some commonalities in evacuations from deliberate and nondeliberate disasters, particularly relating to response and recovery. For example, response parallels exist between wildfires and arson, accidental explosions and bombs, airplane accidents and aviation terrorism, floods and dam sabotage, chemical releases and chemical attacks, and epidemics and biological terrorism (Demuth, 2002).

THE CHANGING TECHNOLOGICAL AND SOCIAL CONTEXT OF WARNINGS

Warning processes have traditionally been linear communication systems. In a linear process, governmental organizations identify the presence of a hazard through validated monitoring and detection systems. The data are then assessed and analyzed and could lead to the prediction of an extreme event. Such predictions typically included a forecast of the estimated lead time until impact, general location to be affected, estimated magnitude of the event, the probability of occurrence, and the likely consequences for residents. The organizations making these predictions communicate the information to public emergency officials, who in turn interpret the information, decide whether to warn, determine the content of the warning, decide the

method to disseminate the message, and then issue the warning to citizens. Again, such a system is linear, going from one actor to the next. The warning that eventually gets to citizens at risk is official. People at risk are expected to respond to these official warnings. This warning process has served our nation for over a half a century, and may still be of use in rural areas with widely dispersed population and few resources.

Significant changes in American society have occurred since this linear warning process was developed. Both cultural and technological shifts in the last decade have altered our view of the public warning process and require a different approach to planning and issuing warnings. These changes include:

- new warning technologies (cell phones, Internet, pagers, palm pilots)
- private warning subscription providers,
- nationalization of news coverage,
- increased availability of visual images and information, and
- increased use of a Global Positioning System (GPS) for alert and notification.

In addition to technological changes, societal changes have impacted the warning process. Today the public does not rely on a single official source of warning information. Instead, people access or are forced to listen to multiple sources of information, some of which may be unreliable or not supported by valid models or detection systems. Increasing transmission of warning messages now compete for an individual's attention creating problems especially for fast-moving events with no communication cues. Media coverage of high-consequence/low-probability events draws attention from more common occurring risks for which warnings generally protect people. To further compound the problems America's increasing ethnic diversity with a multiplicity of languages has created more barriers to communication with minority groups at the same time that the number of such groups has grown tremendously.

Demographic changes have also affected warning communications. Increases in single-person, single-parent, and elderly households have affected people's abilities to respond to warnings, or even to respond at all. Added to these problems is the increase in residential and institutional development in vulnerable areas (especially coastal surge zones) that has led to greater number of special populations at risk. Placing nursing homes and assisted living facilities on exposed barrier islands further saps scarce resources for communities that must also plan for evacuating large seasonal tourist populations who may never have experienced an evacuation.

THE RESEARCH RECORD

The empirical study of public evacuation and response to emergency warnings has proceeded for more than 40 years (Baker, 1979; Drabek & Stephenson, 1971; Lachman, Tatsuoka, & Bonk, 1961; Leik, Carter, Clark, Kondall, Gifford and Ekker, 1981; Mileti & Beck, 1975; Perry & Mushkatel, 1986, 1984; Quarantelli, 1980a). These studies, when viewed collectively, have compiled an impressive record about how and why public behavior occurs in the presence of impending disaster or threat. For example, it is well documented that emergency warnings are most effective at eliciting public protective actions such as evacuation when those warnings are frequently repeated (Mileti & Beck, 1975), confirmatory in character (Drabek & Stephenson, 1971) and perceived by the public as credible (Perry et al., 1981). Excellent summaries of

TABLE 11.1. Behavioral Surveys on Evacuation Behavior of Residential Population in the United States

Event	Source
Rio Grande flood	Clifford, 1956
Hilo Tsunami	Lachman et al., 1961
Hurricane Carla	Moore et al., 1964
Hurricane Camille	Wilkinson & Ross, 1970
Denver flood	Drabek & Stephenson, 1971
Rapid City flood	Mileti & Beck, 1975
Big Thompson flood	Gruntfest, 1977
Hurricane Eloise	Windham et al., 1977
Hurricane Eloise	Baker, 1979
Three Mile Island nuclear accident	Cutter & Barnes, 1982; Flynn, 1979
Mississauga chemical accident	Burton, 1981
Sumner flood	Perry et al., 1981
Valley flood	Perry et al., 1981
Fillmore flood	Perry et al., 1981
Snoqualmie flood	Perry et al., 1981
Clarksburg flood	Leik et al., 1981
Rochester flood	Leik et al., 1981
Hurricane David	Leik et al., 1981
Hurricane Frederick	Leik et al., 1981
Mt. St. Helens volcano	Perry & Greene, 1983
Mt. St. Helens ash	Dillman et al., 1983
Abilene flood	Perry & Mushkatel, 1984
Mt. Vernon chemical accident	Perry & Mushkatel, 1984
Denver chemical accident	Perry & Mushkatel, 1986
Hurricane Elena	Baker, 1987, Nelson et al., 1989
Hurricane Kate	Baker, 1987
Confluence PA chemical spill	Rogers & Sorensen, 1989
Nanticote chemical accident	Duclos et al., 1989
Pittsburg PA chemical spill	Rogers & Sorensen, 1989
Hurricane Andrew	Gladwin & Peacock, 1997
Hurricane Bertha	Dow & Cutter, 1998
Hurricane Fran	Dow & Cutter, 1998
Hurricane Georges	Dash & Morrow, 2001; Howell, 1998
Helena AR chemical accident	Vogt & Sorensen, 1999
Hurricane Brett	Prater et al., 2000
Hurricane Bonnie	Whitehead et al., 2000
Hurricane Floyd	Dow & Cutter, 2002; HMG, no date
Hurricane Ivan	Howell & Bonner, 2005

this research currently exist (Drabek, 1986; Lindell & Perry, 2004; Mileti & Sorensen, 1988; Tierney, Lindell, & Perry, 2001). Studies and summaries like these have done much to further social scientific understanding of how people process and respond to risk communications in emergencies; they have also served to inform practical emergency preparedness efforts in this nation and abroad.

The empirical research record on public behavior in evacuations is listed in Table 11.1. These studies represent major post-disaster surveys of the public that resided in areas for which a warning of an impending disaster was issued. The warning or warnings that were officially issued for these events included an order or advisory for the public to evacuate. Each study

represents the following common characteristics:

- a discrete event took place,
- a clear threat to the population was present,
- an official warning was issued, and
- a more or less random sample of the population at risk served as the basis for the survey on which the researcher(s) compiled data on public evacuation behavior.

Disaster researchers have also studied evacuation behavior for discrete populations or in specific settings. Drabek (1996) studied tourist and transient behavior in Hurricanes Bob, Andrew, and Iniki and in the Big Bear Lake and Northridge earthquakes. Vogt (1990, 1991) examined evacuation of institutionalized facilities including hospitals, nursing homes, and schools. Drabek (1999) studied the evacuation behavior of employees in 118 businesses in seven disaster events around the country. Aguirre and colleagues (1998) and Fahy (1995) examined evacuation behavior of building occupants following the 1993 bombing at the WTC. More recently an extensive study about evacuation of the WTC on September 11 was conducted (Averill et al., 2005). Kendra, Wachtendorf, and Quarantelli (2002) examined the evacuation of Manhattan by water transport. Heath, Kass, Beck, and Glickman (2001a, 2001b) studied the evacuation of families with pets in a hazardous material accident and in a flood.

MAJOR RESEARCH FINDINGS

Warnings and Warning Response

These research questions focus on the information dissemination process, the quality of the information, and the timing of the message delivery and compliance with the warnings. Hurricanes and riverine floods typically have long warning periods during which both information on the physical characteristics of the event and recommendations on protective actions are widely distributed, often over national media outlets. Other incidents have a very short time span between detection and impact and require rapid warnings. For a radiological emergency at a nuclear power plant or a chemical release, emergency personnel may elect to shelter-in-place populations at potential risk instead of recommending evacuation. Some communities, with many large industrial facilities, recommend that residents initially shelter-in-place when sirens sound and then listen for further instructions to evacuate or not (Sorensen, Vogt, & Shumpert, 2004). Some research (Three Mile Island, the West Helena explosion) indicates that residents will often defy official recommendations and evacuate even when told to shelter or advised that no protective action is needed. Among the important topics that disaster researchers have studied with respect to warning and response are:

- community adoption of warning systems,
- the timing of warning receipt and warning diffusion, and
- factors influencing household decisions to respond to warnings.

Adoption of Warning Systems

Only a few researchers have investigated the community adoption of warning systems at the community level. Most research concerning adoption has focused on mitigation at either at the community (Berke, Beatley, & Wilhite, 1989) or household (Lindell, 1997) level. A

study reviewing community emergency evacuations (Hushon, Kelly, & Rubin, 1989) found the methods most often used for notification and warning were door-to-door warnings coupled with emergency vehicle public address systems and TV and radio announcements. A survey of 18 early warning systems in the United States developed to protect communities against flash floods and dam failures revealed problems of unanticipated maintenance and malfunction costs of the warning systems' components, varying levels of local commitment to maintenance, and an underemphasis on response capacity (Gruntfest & Huber, 1989).

One of the few national studies of community preparedness for chemical hazards conducted by EPA looked at the types of warning systems used by communities with hazardous materials industries (Sorensen & Rogers, 1988). Warning systems were classified into three basic types: enhanced systems, siren-based systems, and ad hoc systems. Enhanced systems use sirens and some form of specialized alerting such as tone alerts. Siren-based systems rely on sirens for alert with use of media-based notification (if the siren has no voice capability to broadcast a warning message). Ad hoc systems generally rely on media reports, an Emergency Alert System (EAS), and on door-to-door or route alert. The study found that the predominant means to warn people in close proximity of the chemical facilities was usually by an ad hoc method (45%). Sixteen percent relied on route alert or door-to-door notification. Another 29% relied on EAS or media warnings. Siren-based systems were utilized in 33% of the communities. Only 12% had access to an advanced system involving both sirens and tone-alert radios for notification.

Timing of Warning Receipt

Overall we have good insight into timing of warning dissemination. Much of this knowledge has been derived by contentions over warning systems for nuclear power plants, primarily as a result of Atomic Safety Licensing Board (ASLB) rulings. The most significant debate on what constitutes a state-of-the-art alert/notification system came in an ASLB proceeding on the Shearon Harris Nuclear Power Plant in which disaster researchers served as expert witnesses. In their final decision the ASLB defined what constitutes "essentially 100% notification within 15 minutes in the first 5 miles of the Harris Emergency Planning Zone (EPZ)" (NRC, 1986). In this matter, the board required the utility to prove that more than 95% of the people within 5 miles of the facility would receive a warning in 15 minutes in summer nighttime conditions, one of the most difficult warning times. The utility could not do so by relying solely on a siren system. To exceed the 95% requirement, commercial tone alert radios were proposed for all households within the 5-mile radius. The ASLB accepted this plan as exceeding 95% notification.

Researchers have modeled the timing of warning dissemination for specific events with multiple sources (Lindell & Perry, 2004) or for different warning technologies (Rogers & Sorensen, 1988). Often warning time is broken down into the decision time (time for officials to reach a decision to issue a warning) and dissemination time (the time it takes for the message to reach the public) (Lindell & Perry, 1992; Rogers, 1994). Once the warning is given, a mobilization time or preparation time (referring to the time taken to prepare to implement the protective action) is modeled. Implementation time is defined as when the protective action is undertaken. Mobilization times are highly variable and seem to depend on the time to impact and the level of urgency to respond (Lindell & Perry, 1992).

Survey data collected on the Nanticoke, Pennsylvania, evacuation due to a metal processing plant fire enabled the construction of empirically derived diffusion curves for different

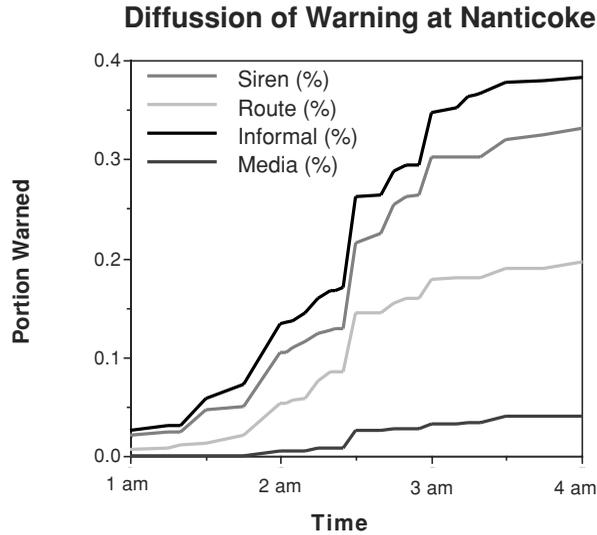


FIGURE 11.1. Source of first warning by warning technology.

warning technologies (Sorensen, 1992). The curves show the cumulative percent of the population receiving the first warning over time by the four major methods of warning. These are shown in Figure 11.1. The timing of the diffusion is very similar for siren, route, and informal alerting. Some of the early reporting of sirens and route alerts were likely made by people who heard emergency vehicles responding to the fire. The curves show a steep increase in notification when the official warning activity ensued. Data indicate that by 15 minutes into the official warning, about 65% of the public had been notified. About 22% of the public had received a siren warning at this point. The remainder had received an informal warning, from route alert or from the media.

Little research has been conducted on explaining individual variations in the timing of response (Sorensen, 1992). For example, what differentiates early or rapid responders from those who delay their response?

Factors Influencing Household Decision to Evacuate

A robust understanding of factors influencing evacuation compliance has been developed by social science researchers. The focus of the research has been on whether or not people evacuate when advised to do so (see Anderson, 1969; Baker, 1979; Cutter & Barnes, 1982; Dow & Cutter, 1998; Drabek, 1969, 1983; Drabek & Boggs, 1968; Drabek & Stephenson, 1971; Lachman et al., 1961; Leik et al., 1981; Lindell & Perry, 2004; Mileti, 1975; Mileti & Sorensen, 1988; Perry, 1979; Perry & Greene, 1982, 1983; Perry & Mushkatel, 1984, 1986; Perry et al., 1981, 1982; Quarantelli, 1980b, 1984a; Stallings, 1984; Williams, 1964; Withey, 1962).

Warning response involves a sequence of cognitive and behavioral steps. Perry and Lindell (1992, 2004a) characterize warning response as a four-stage process:

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

Mileti and Sorensen (1988) characterize the process as sequential:

- *Hearing* the warning;
- *Understanding* the contents of the warning message;
- *Believing* the warning is credible and accurate;
- *Personalizing* the warning to oneself;
- *Confirming* that the warning is true and others are taking heed; and
- *Responding* by taking protective action.

Social scientists have identified both general and specific factors that affect the warning response process which include sender and receiver factors, situational factors, and social contact. The specific factors are summarized in Table 11.2 (Sorensen, 2000). Only a few of these factors can be manipulated as part of the warning process. The chief way warning response can

TABLE 11.2. Major Factors Covarying with Evacuation Compliance

Factor	Direction: As factor increases likelihood of evacuation . . .	Level of Empirical Support
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	Moderate
Age	Mixed	High
Socioeconomic status	Increases	High
Being female vs. male	Increases	Moderate
Having children	Increases	Moderate
Pet ownership	Decreases	Low
Channel: Electronic	Mixed	Low
Channel: Media	Mixed	Low
Channel: Siren	Decreases	Low
Personal warning vs. 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	Increases	High
Fear of looting	Decreases	Moderate
Time to impact	Decreases	Moderate
Source familiarity	Increases	High

Source: Modified from Sorensen, 2000.

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 for evacuated areas (Lindell & Perry, 1992).

One frequent response to a warning is to confirm the original message received (Drabek, 1969). Confirmation increases with longer lead-time to impacts (Perry et al., 1981), for warnings received from the media (Dillman, Schwalbe, & Short, 1983; Sorensen, 1992), and for alerts received by sirens (Sorensen, 1992). Confirmation levels decrease with the specificity of information in the first warning received (Cutter & Barnes, 1982) and when the initial warning is heard from police and fire personnel going door to door or using loudspeakers (Sorensen, 1992).

SOCIETAL CHARACTERISTICS

This research centers on the pre-emergency population attributes, including psychological, demographic, and social characteristics of those at risk. How a threat or potential risk is perceived and how (or if) people respond, especially in a rapid onset event, are often determined by existing conditions, including individual vulnerability. Some researchers have found that existing problems among population groups, such as domestic violence, escalates during disasters, especially if they include evacuation to a shelter or loss of residence (Enarson, 1998). Among the topics that disaster researchers have studied with respect to social issues are:

- how experience affects evacuation decisions,
- depersonalization and denial of risk,
- impact of preparedness effort on evacuation, and
- the relationship between culture, ethnicity, vulnerability, and evacuation.

How Experience Affects Evacuation Decision

Experiencing a disaster or a close call with an event often shapes people's response to future events; however, it does not do so in a predictable or systematic way. Direct hazard experience does not effect interpretation of warning information, decision processes, behavior, or information seeking (Lindell & Perry, 2004). Hurricane Kate led to an evacuation of the Tampa Bay area about 4 months after Hurricane Elena had prompted an unnecessary evacuation of the same area. Baker (1987) found that evacuation rates in the Tampa Bay area for Hurricane Kate were similar to that for Elena, despite the earlier false alarm. Others have suggested that long-term residents of coastal areas, who experienced minor hurricanes without severe damages, become complacent, and are less likely to evacuate in subsequent events (Windham, Posey, Ross, & Spencer, 1977). Others have suggested previous experience has had a positive effect on warning response (Lindell & Perry, 2004).

Personality, Depersonalization, and Denial of Risk

There has been a fairly widespread belief that personality factors such as locus of control (it is in the hands of others) or fatalism (what will happen will happen regardless of what I do)

affect evacuation behavior. This is mainly supported by anecdotal information or newspaper coverage of people who refuse to evacuate and not by extensive empirical research. Good anecdotal examples are Harry Truman, who refused to leave his cabin near Mt. St. Helens volcano when warned because he felt his fate was in the hands of a higher authority (he died during the eruption) or people having hurricane parties. Several studies have concluded fatalism diminishes warning response for earthquakes (Turner, Nigg & Paz, 1986) and for tornados (Sims & Baumann, 1972). When faced with a warning to evacuate people often are initially in disbelief—it's not really happening to me (Drabek, 1999). Usually such perceptions are rapidly replaced by the reality of the situation.

Impact of Preparedness Efforts on Evacuation

There is no conclusive evidence regarding whether or not preparedness programs, public education, or information programs actually make a significant difference in increasing human response to warnings. The most reasonable interpretation of the evidence, when considering the empirical, anecdotal, and practical is that a good pre-emergency information program will increase response although the amount cannot be estimated (Sorensen & Mileti, 1991). Conversely, a poor program will not likely make a great overall difference. In addition, while providing information may lead to increased knowledge and preparedness, the effects drop off over time (Waterstone, 1978).

The Relationship Between Ethnicity, Culture, Vulnerability, and Evacuation

Some researchers argue that membership in a minority group typically isolates a person from information and decreases the likelihood of responding to a warning (Gladwin & Peacock, 1997; Perry et al., 1981). Other studies demonstrate that ethnicity has no significant effect on evacuation when perceived risk has the greatest influence (Perry, 1987). Language—the inability to understand the warning message—may also be a factor explaining why culturally isolated groups fail to understand a warning. The high number of deaths of Hispanics in the Saragosa, Texas tornado was attributed to a failure to provide a good translation of the warning into Spanish (Aguirre, Anderson, Balandran, Peters, & White, 1991).

In general, the literature suggests that members of minority ethnic groups are less likely to evacuate in an emergency (Mileti & Sorensen, 1988). Perry (1987) offers evidence that suggests that there appears that no ethnic differential exist with regard to the evacuation behavior when the relationships between warning belief and personal risk are controlled for. Perry (1987) also suggests from his research that some minority group members perceive authority figures—particularly uniformed “government” representatives—differently from majority group members. The higher the credibility of the warning source, the more likely the development of high levels of warning belief and the assessed personal risk, and consequently the more likely the recipient will engage in a protective action. Thus emergency managers should understand the authority figures that are regarded as credible by various population groups and have them issue warnings to achieve maximum warning compliance.

Wisner et al. (2004) offers a definition of vulnerability as it relates to hazards by suggesting vulnerability is defined by a combination of factors that influence people's ability to anticipate, cope with, resist, and recover from an identifiable event in nature or society. There is a time dimension to the definition as well, as Wisner et al. (2004) notes that vulnerability cannot

be measured in immediate damages but takes into account damages to future livelihoods due to a person's (or group's) lack of resources and capacity to rebound. Although not directly related to poverty, though clearly related to socioeconomic status, Wisner's work relates to technological and terrorist events as well, and could be used for any threat that places people at risk relative to evacuation issues.

We currently know little about the social aspects of vulnerability. Social vulnerabilities, such as loss of community, are largely ignored, mainly because of the difficulty in quantifying them, which also explains why social losses are normally absent in after-disaster cost/loss estimation reports. The social mediation of vulnerability is also often overlooked (Cutter, Hodgson, Dow, 2001). Instead, social vulnerability is most often described using the individual characteristics of people (age, race, health, income, type of dwelling unit, employment). Socially mediated vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond. However, it also includes place inequalities—those characteristics of communities and the built environment, such as the level of urbanization, growth rates, and economic vitality, that contribute to the social vulnerability of places. To date, there has been little research effort focused on identifying socially constructed vulnerabilities or on comparing the social vulnerability of one place to another.

ORGANIZATIONAL RESPONSE

Typically this research has focused on the behavior of emergency preparedness and response organizations and their capacity to scale up to their response and resources if the event expands or secondary hazards occur. Among the topics that disaster researchers have studied with respect to organization are:

- the relationship between planning and response effectiveness;
- improving behavioral assumptions in planning; and
- reentry into evacuated areas, especially if decontamination effectiveness is problematic.

The Relationship Between Planning and Response Effectiveness

Evacuation warnings given without forethought or planning and without input from partners can be disastrous to both sender and receiver. It is important to plan for warning credibility, the warning message, the method of dissemination, rumor control, protective action recommendations, and incentives to response (Lindell and Perry, 2004; Mileti & Sorensen, 1990). Moreover, a warning may not be heeded by the public when the information is in direct contrast to what is being observed. To be most effective, a warning message should be planned with the concerted efforts to tell people where, when, how, and why the hazard has occurred (or is predicted to occur) and what people can do to avoid harm (Lindell & Perry, 2004). Plans should include the lead partner who will issue warnings for specific events.

Flexibility is also an essential element in planning and disseminating warnings (Mileti & Sorensen, 1990). A particular issue is how the hazard is defined, and therefore who is in charge. If an event is considered a potential crime scene, the emergency agencies responding may not be the ones who issue follow-up messages about the hazard. The key is to develop procedures to avoid conflicts in information in warning messages, recognizing that partnerships will fluctuate as the event unfolds.

Improving Behavioral Assumptions in Planning

Many emergency planning processes now involve the use of simulation models. All models concerning disaster management contain assumptions about human beings, be it an engineer's cognitive model of an equipment failure mode or a psychologist's model of how people respond to a stimulus. Few efforts have been made to identify and document behavioral assumption in models developed for and used in disaster management. It is essential that critical assumptions used in models be validated. For example, Lindell and Perry (1992) noted that the assumptions about warning and preparation times used in evacuation time estimates are based on engineering assumptions and not on behavioral data.

More work is need to develop robust models of human behavior in emergencies, including models of decision making, communication, interaction, warning systems, and protective action behaviors. For example, some dose assessment models assume people are passive receptors of an agent or are located in the same place during daytime as well as nighttime hours. Models based on these assumptions might not apply when people are fleeing or taking precautions in place. Santos and Aguirre (2004) argue that simulation models for emergency planning and intervention need to be linked to fieldwork and empirical investigations of emergency evacuations in order to provide modelers with the appropriate parameters for human behavior.

Reentry Into Evacuated Areas

Planning for reentry remains an issue that is often not addressed in plans. What is known on reentry procedures is not always implemented in practice. We know residents want to return as soon as possible to evacuated homes, that they do not travel far from home, and that considerable antagonism results if they are forced to remain away from their homes (Dash & Morrow, 2001). Research from Hurricane Elena evacuees indicated that approximately 75% of evacuees sought refuge in their home counties and reentry to designated evacuated areas became a significant issue (Nelson, Crumley, Fritsche, & Adcock, 1989).

Guidelines for reentry into an area following a chemical release are practically nonexistent as are protocols and equipment for environmental monitoring in areas evacuated (Vogt & Sorensen, 2002). In the Miamisburg, Ohio, white phosphorus accident, citizens returned to their homes after being evacuated only to be forced to evacuate again as the situation worsened (Menker & Floren, 1986).

Managing traffic during reentry can be more problematic than during the evacuation. Witzig and Shillenn's (1987) study of traffic accidents in more than 300 evacuations traffic jams showed they were more likely during reentry than in the movement out.

BEHAVIOR IN EVACUATIONS

This category of research focuses on actual behavior in evacuations (and sheltering-in-place). Among the major research topics are:

- evacuation compliance,
- evacuation of special populations,
- evacuation of pets, and
- evacuation destinations.

Compliance with Evacuation Recommendations

Disaster researchers have studied issues associated with compliance with official orders to evacuate or not to evacuate. Such issues concern “shadow” evacuation, defined as people evacuating from outside the official evacuation zone, “early” or “spontaneous” evacuation, defined as people evacuating before an official warning is issued, evacuation rates in different risk zones, and “cry-wolf” effects. “Cry wolf” effects are defined as the noncompliance with warnings behavior that might be expected from residents who have responded to too many “false alarm” warning messages. “Warning fatigue” and the design of warning messages for special populations with limited sight or hearing have also been discussed in the literature but not in the same depth as the subjects previously mentioned (Mayhorn, 2004).

Evacuation rates vary by event, depending on the timing, perceived severity, constraints, susceptibility, and cost (Drabek, 1986). When warned properly, significant proportions of the threatened population respond in a reasonable manner (Drabek, 1986). In most evacuations, not everyone at risk or in areas in which evacuations are ordered or recommended, participate in the evacuation. Reasons for noncompliance include not having access to transportation, being mobility impaired, not being able to afford to evacuate, needing to work, needing to provide care, and thinking one’s location is safe. Evacuation rates vary for different hazard types, for different events, and for different level of risk (as defined geographically). Evacuation rates are very high for most hazardous material accidents, where compliance may be in the high 90% range. Evacuation rates are typically low for slow onset events such as riverine floods. Evacuation rates vary in hurricanes depending on the strength of the storm and location. In high-hazard storm surge area evacuation rates may be as high as 90% in major storms. Evacuation rates are much lower for smaller hurricanes and in lower risk zones.

“Shadow evacuation” was well documented for Hurricane Floyd. The Hazards Management Group of Tallahassee, Florida (2000) studied the public’s response to Hurricane Floyd in 1999 through 6900 structured telephone interviews with North Carolina, South Carolina, Georgia, and Florida residents in surge and nonsurge areas, as well as residents in noncoastal areas. Results revealed some of the highest participation rates ever experienced in an evacuation in the high-risk surge zone. Most evacuees cited evacuating because of notices from public officials and what they heard on the Weather Channel and local weather stations. A large percentage of respondents sought refuge out-of-county and out-of-state, with very few seeking refuge in official shelters. The data indicate that “shadow evacuation” in low-risk areas not told by officials to evacuate was high in almost every location. For example, evacuation rates in noncoastal counties, the lowest risk zone, ranged from 12% to 49%, with an average of 26%.

The concept of “spontaneous” evacuation grew out of analyses of the evacuation at Three Mile Island, when many more people evacuated than were advised to leave (Cutter & Barnes, 1982). In fact, spontaneous evacuation occurs in most evacuation events. People leave coastal areas when a hurricane seems eminent before officials order or recommend evacuation. In hazardous material accidents plant workers or first responders contact friends and relatives thought to be at potential risk before an official evacuation order (Vogt & Sorensen, 1999).

The effectiveness of people’s responses to warnings is not always diminished by what has been labeled the “cry-wolf” syndrome. Two issues regarding false alarms are significant. The first concerns a false alarm that leads to the public taking a protective action such as evacuating. In this case, if the bases for the warning and reasons for the “miss” are told to

the public in question and understood by them, the integrity of the warning system will be preserved. Data from hurricane evacuation studies indicate that false alarms do not prevent people from evacuating in the future if they know the basis for the uncertainty and the false alarm (Baker, 1987).

The second issue related to the “cry wolf” syndrome concerns repeated activation of the alert mechanisms. If such false alarms occur and no attempt is made to explain why they were false alarms, there could be a negative effect on subsequent public response to warning of a subsequent event (Breznitz, 1984). This is particularly true of inadvertent sounding of sirens if such malfunctions are frequent and not explained. It may also occur in populations around industrial facilities that use sirens to signal work shift changes.

Animals in Evacuations

Most disaster relief shelters or commercial lodging facilities do not allow people to bring in pets or other animals unless they are designated as certified companion animals for persons with disabilities. The Federal Emergency Management Agency (FEMA), however, recommends people evacuate with pets. An issue receiving increasing attention is what evacuees do with pets or other animals such as livestock when they leave their homes and whether having pets or animals impacts their decision to evacuate. Nelson et al. (1989) found that in Hurricane Elena, 25% of evacuees left their pets at home while they were gone. Most evacuees took their pets to either a friend or relative. The 11% of evacuees who took their pets to shelters left the animals in vehicles for the duration of the stay. Heath (2001b) found that in a flood evacuation, half of the pet owners evacuated with their pets and the other half did not.

For a protracted evacuation or one in which toxic fumes were involved, leaving pets behind could be a significant problem as premature reentry by evacuees could place residents at further risk. Cann (1990) found that during the 10-day Hagersfield evacuation from an area where burning tires created toxic fumes, residents routinely returned to their homes to care for livestock. Heath (2001a) found that in a chemical accident, 60% of the evacuees had dogs and cats. Of those, 49% evacuated with their pets, 41% initially left them home but later attempted to rescue them, and only 10% left them home without a rescue attempt. Buck (1987) notes that in certain situations evacuating livestock may be the only measure offering protection to animals. How that is best accomplished under various time frames remains problematic. Nelson et al. (1989) found that in Hurricane Elena people who had pets at the time of the hurricane were less likely to evacuate. Similar results were found in a study of evacuation behavior in Hurricane Bonnie (Whitehead et al., 2000).

Evacuation of Special Populations

Special populations are those groups of people who because of their special situations or needs require planning strategies different from those of general evacuation planning (Vogt, 1990, 1991). The term “special population” is somewhat misleading in that populations of institutions or special facilities are frequently considered homogeneous when in reality they exhibit many characteristics that differ by physical or geographic constraints (Lindell et al., 1985). While some populations may be concentrated in institutions such as schools, prisons, or hospitals, other will be widely dispersed. Among the dispersed individuals who make up such groups are the hearing or visually impaired, the non-English-speaking, transients

such as motorists passing through the area, tourists or other temporary visitors such as day workers, and nonambulatory individuals confined to residences either temporarily or permanently.

The reason why these groups may fail to respond to warnings to take protective actions is that some groups may require special transportation while others require different types of warnings or technologies to receive a warning. Some groups must rely on caregivers (such as schools and daycare centers) to hear the warning and respond. Populations of nursing homes or assisted care facilities may combine various aspects related to mobility and mental competence that makes evacuation the last resort in protective action planning. Lack of mobility may not be voluntary, as in the case of prisons where continued constraints must be imposed during the evacuation process.

Destinations of Evacuees

Despite efforts by public officials to provide public shelters to house evacuees, most people evacuate to relatives, friends, or hotels. The use of public shelters is variable, ranging from less than 1% for the Three Mile Island evacuation to more than 40% in the Nanticoke hazardous materials evacuation. On average, shelter use is about 13%. It appears to be higher when the evacuating population is of low income and older and lower when the population is more affluent and young (Mileti, Sorensen, & O'Brien, 1992).

CONCLUSIONS

With the exception of hurricanes, very little research has been conducted in the past 10 years on warning and evacuation. Most of our understanding of human response to warnings is based on older research that has been based primarily on theories of persuasive communication. This linear model assumes a top-down flow of "official" warning information to the public. We suspect that this communication model, not without merit, needs to be revised. Social and technological changes have opened gaps in our knowledge about responses to warnings that requires research that will refine or replace extant theories.

We do not know the degree to which we can use past history to understand and predict how people will respond to events not yet experienced in our society, such as suicide bombings, a release of a biological agent, an attack with a radiological dispersion device, or a release of a chemical warfare agent. We will learn more about consistency and change in disaster response as we systematically study human response in new types of disasters. Preliminary findings from the large number of post-9/11 investigations suggest that some types of behaviors are similar to those exhibited in other large-scale disasters (such as the general absence of panic and considerable altruistic behavior). Other types of post-9/11 behavior, such as avoidance and economic spending, were unique. We must continue to document differences and consistencies in disaster responses and learn what variables systematically shape them. This might require not just retrospective research but also rapid response teams of social scientists who, without interfering with emergency operations, can document behavior as it is occurring or very soon thereafter in a systematic and scientific manner.

Hurricanes Katrina and Rita caused large-scale evacuations of coastal areas in Mississippi, Louisiana, and Texas. Future research on these two events will likely provide opportunities

to examine evacuation problems and strategies for large urban areas when a great level of infrastructure is destroyed. Such research will also add to the existing knowledge base on sequential hazards. The flooding of New Orleans from levee failure was a secondary event while wind and storm surge was the cause of destructive flooding for others along the Gulf coast affected by the same hurricane.