Risk Analysis, Vol. 32, No. 4, 2012 DOI: 10.1111/j.1539-6924.2011.01647.x

The Protective Action Decision Model: Theoretical Modifications and Additional Evidence

Michael K. Lindell[1,*] and Ronald W. Perry[2]

The Protective Action Decision Model (PADM) is a multistage model that is based on findings from research on people's responses to environmental hazards and disasters. The PADM integrates the processing of information derived from social and environmental cues with messages that social sources transmit through communication channels to those at risk. The PADM identifies three critical predecision processes (reception, attention, and comprehension of warnings or exposure, attention, and interpretation of environmental/social cues)—that precede all further processing. The revised model identifies three core perceptions—threat perceptions, protective action perceptions, and stakeholder perceptions—that form the basis for decisions about how to respond to an imminent or long-term threat. The outcome of the protective action decision-making process, together with situational facilitators and impediments, produces a behavioral response. In addition to describing the revised model and the research on which it is based, this article describes three applications (development of risk communication programs, evacuation modeling, and adoption of long-term hazard adjustments) and identifies some of the research needed to address unresolved issues.

KEY WORDS: Protective action decisions; protective action perception; risk perception

1. INTRODUCTION

Researchers have long been interested in explaining the process by which people respond to environmental cues or socially transmitted warnings about environmental hazards and disasters.[1–10] Findings from this research on environmental hazards and disasters are compatible with those from theories on social influence, persuasion, behavioral decision making, attitude-behavior relationships, protective action, and innovation processes in identifying useful guidance on ways in which risk communication can influence immediate disaster response and long-term hazard adjustments. The latter are defined, following Burton, Kates, and White,[11] as "those actions that intentionally or unintentionally reduce risk from extreme events in the natural environment" (Ref. 12 p. 328). The relevant elements of these complementary approaches have been integrated to produce a Protective Action Decision Model (PADM) of the factors that influence individuals' adoption of protective actions.[5,13] More recently, additional evidence has been collected that supports some of the PADM's propositions and has required reconsideration of others. Thus, the purpose of this article is to describe an updated version of the PADM, describe three applications (development of risk communication programs, evacuation modeling, and adoption of long-term hazard adjustments), and identify some of the research needed to address unresolved issues. This section will

[1]Texas A&M University, Hazard Reduction & Recovery Center, College Station, TX, USA.
[2]Arizona State University, School of Public Affairs, Phoenix AZ, USA.
*Address correspondence to Michael K. Lindell, Texas A&M University, Hazard Reduction & Recovery Center, College Station, TX 77843-3137, USA; mlindell@tamu.edu.

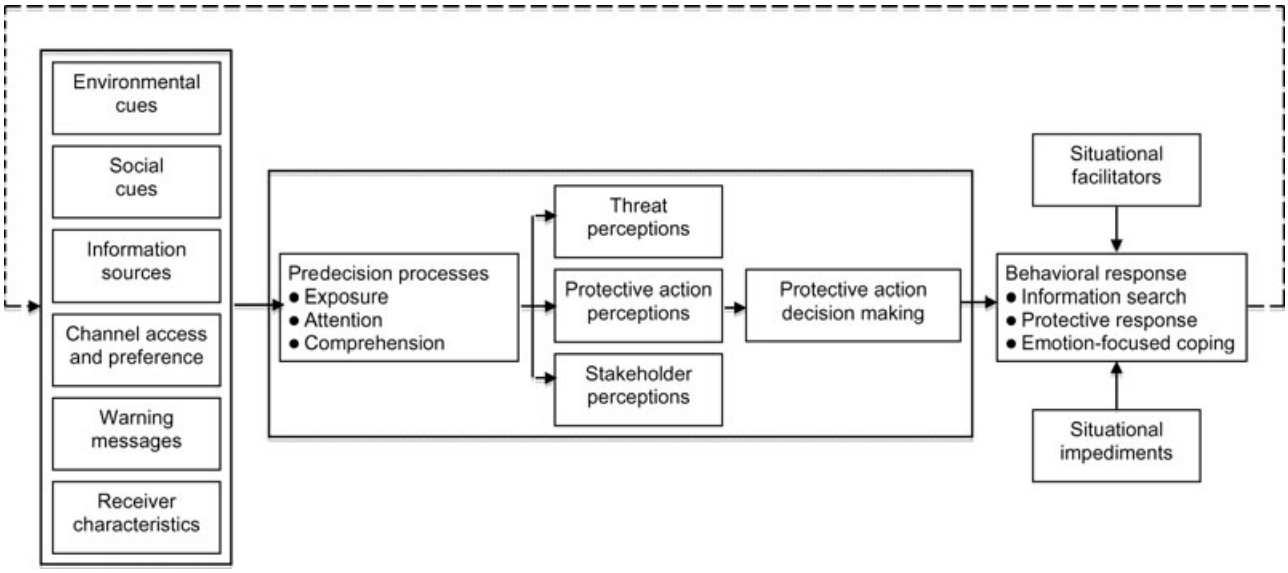

Fig. 1. Information flow in the PADM.
Source: Adapted from Lindell & Perry (2004).

provide a brief overview of the model, which will be followed by more detailed discussion of its components in Sections 2–5. Section 6 will provide a theoretical assessment of the PADM and Section 7 will describe its applications in three areas (development of risk communication programs, evacuation modeling, and adoption of long-term hazard adjustments).

The findings of studies on individual response to environmental hazards and disasters can be diagrammed in a flow chart that provides a graphic representation of the model (see Fig. 1). The process of protective action decision making begins with environmental cues, social cues, and warnings. Environmental cues are sights, smells, or sounds that signal the onset of a threat whereas social cues arise from observations of others' behavior. Warnings are messages that are transmitted from a source via a channel to a receiver, resulting in effects that depend on receivers' characteristics. The relevant effects are changes in receivers' beliefs and behaviors, whereas receivers' characteristics include their physical (e.g., strength), psychomotor (e.g., vision and hearing), and cognitive (e.g., primary and secondary languages as well as their mental models/schemas) abilities as well as their economic (money and vehicles) and social (friends, relatives, neighbors, and co-workers) resources.

Environmental cues, social cues, and socially transmitted warnings initiate a series of predecisional processes that, in turn, elicit core perceptions of the environmental threat, alternative protective actions, and relevant stakeholders. These perceptions provide the basis for protective action decision making, the outcome of which combines with situational facilitators and impediments to produce a behavioral response. In general, the response can be characterized as information search, protective response (problem-focused coping), or emotion focused coping. In many cases, there is a feedback loop as additional environmental or social cues are observed or warnings are received. The dominant tendency is for such information to prompt protective action decision making, but information seeking occurs when there is uncertainty at a given stage in the protective action decision-making process. Once the uncertainty is resolved, processing proceeds to the next stage in the process.

The stages in the PADM characterize the way people "typically" make decisions about adopting actions to protect against environmental hazards. These stages are sequential, as are those within the information-seeking process. However, few people are likely to follow every step in the model in the exact sequence listed in Fig. 1. For example, an extremely credible (or powerful) source might obtain immediate and unquestioning compliance with a directive to evacuate an area at risk—even if there were no explanation why evacuation was necessary or what alternative protective actions were feasible.[14] The important lesson is that—unless warning sources have an extreme amount of credibility or they have substantial power to compel compliance—the more stages in the PADM they neglect, the more

ambiguity there is likely to be for message recipients. In turn, greater ambiguity is likely to cause warning recipients to spend more time in seeking and processing information rather than preparing for and implementing protective action.[9,15] Indeed, ambiguity can initiate a repetitive cycle of information processing and information seeking that persists until it is too late to complete a protective action before hazard onset.

2. ENVIRONMENTAL AND SOCIAL CONTEXT

The physical environmental component comprises the geophysical, meteorological, hydrological, or technological processes that generate a hazard and transport it to the locations where people are exposed (see Ref. 16, chapter 5, for further discussion). These processes generate hazards that vary in the speed of onset, and magnitude, scope, and duration of their impacts. One important hazard characteristic that is often quite relevant for people's emergency response is the availability of environmental cues such as sights and sounds that indicate hazard onset. In tornadoes, for example, the sight of a funnel cloud and a roar "like a freight train" (a common description by tornado victims) provide unmistakable indications of imminent threat. In other cases, such as the recession of coastal waters before a tsunami, the cues are much more ambiguous and likely to be misinterpreted. Still other hazards, such as ionizing radiation and some toxic chemicals, provide no environmental cues whatsoever.

The transmission of social information is based upon the classic six-component communication model of source-channel-message-receiver-effect-feedback.[17–21] Sources in the social context consist of other people who may transmit information about hazards and protective actions, as well as providing assistance to reduce the hazard or providing material resources that assist protective response. For example, authorities, news media, and peers (i.e., friends, relatives, neighbors, and co-workers) can provide information about environmental threats and alternative protective actions. Moreover, emergency managers can dispatch city and school buses to evacuate those who lack their own means of transportation. They can also provide public shelters to those who lack the money needed to stay in commercial facilities or lack nearby friends or relatives with whom to stay.

One crucial aspect of the social context is the network of organizations and individuals that comprise the warning network.[6,22] An original source can transmit a message by means of a broadcast process directly to ultimate receivers (e.g., households) and also by means of a diffusion process through intermediate sources who, in turn, relay messages to ultimate receivers.[23] These ultimate receivers might also transmit messages to each other, thus resulting in some people receiving multiple warnings, others receiving only a single warning, and some people receiving no warnings. The nature of the warning network has a significant impact on protective action decision making because multiple sources often deliver conflicting messages that require searching for additional information to resolve the confusion.

The warning network can communicate information through a variety of different types of channels. These include print (newspapers, magazines, and brochures), electronic (commercial radio and television, telephone, route alert (broadcast from a moving vehicle), tone alert radio, siren, and Internet), and face-to-face (dyadic conversation or group presentation). These channels differ in characteristics such as dissemination rate and precision, penetration of normal activities, message specificity/distortion, sender and receiver requirements for specialized equipment, and feedback/receipt verification (see Ref. 5, chapter 4, for a detailed discussion). Each channel has advantages and disadvantages, with channels that provide the fastest dissemination often providing the least information (e.g., mechanical sirens). Moreover, people differ in their channel access and preferences. For example, tornado warnings broadcast over an English-language radio station missed the population of Saragosa, Texas that routinely listened to Spanish-language stations.[24] In addition to the official warning systems, however, peers typically relay information through informal warning systems. Even when peers do not explicitly transmit warning messages, their behavior—especially obvious preparations for evacuation—can serve as social cues for protective action.[25]

3. PSYCHOLOGICAL PROCESSES

Psychological processes are defined by three sets of activities—(i) predecisional processes; (ii) core perceptions of the environmental threat, alternative protective actions, and social stakeholders; and (iii) protective action decision making. The three predecisional processes of exposure (whether people

receive information), attention (whether they heed it), and comprehension (whether they understand it) are largely automatic processes that take place outside of conscious processing.[26] The three core perceptual objects—environmental threats, alternative protective actions, and societal stakeholders—can elicit either automatic or reflective judgments, depending on the degree to which an individual has schemas that provide readily accessible and coherent beliefs about those objects. When someone has a schema—a generic knowledge structure defined by instances, attributes that differentiate these instances, and interrelationships among the attributes—beliefs about objects encompassed by that schema are rapidly accessed to produce an overall judgment that is congruent with the available information about the situation. Finally, contrary to widespread belief, panic rarely occurs.[27] Instead, protective action decision making is often a reflective process that assesses the available information about the threat, alternative protective actions, and social stakeholders to choose a behavioral response. The research literature suggests that inappropriate disaster responses are more frequently due to inadequate information than to defective cognitive processing.

3.1. Predecisional Processes

Regardless of whether information comes from environmental cues or social warnings, three predecisional processes are necessary to produce a protective response. Information from the physical environment will not lead to the initiation of appropriate protective actions unless people are exposed to, heed, and accurately interpret the environmental cues. Similarly, information from the social environment will not lead to the initiation of appropriate protective actions unless people receive, heed, and comprehend the socially transmitted information. Whether or not people heed the available information is determined by their expectations, competing attention demands, and the intrusiveness of the information.[26] These processes are known to be affected by the warning recipient's age,[28] but the effects of other demographic characteristics have not been reported.

In the case of warnings, people must first receive information from another person through a warning channel and attend to this information. Accordingly, the characteristics of the warning channel itself can have a significant impact on people's reception and attention to warning message content. For example, in many places along the Oregon coast, mountains prevent people from receiving signals from National Oceanographic and Atmospheric Administration Weather Radio transmitters.[29] Even when a warning has been received and heeded, some people will fail to comprehend the available information—what others called "hearing and understanding."[30] The comprehension of warning messages depends upon whether the message is conveyed in words they understand. As the Saragossa tornado indicated, warnings disseminated in English are unlikely to be understood by those who understand only Spanish.[24] In addition, however, comprehension also affected by more subtle factors. A warning message cannot be comprehended if it uses esoteric terms that have no meaning for those at risk. For example, phrases such as "hypocenter" (earthquake), "Saffir-Simpson Category" (hurricane), "oxidizer" (chemical), and "millirem" (radiological) are specialized terms that will not be understood by all who hear them.

3.2. Perceptions of Threats, Protective Actions, and Stakeholders

Unlike comprehension, which provides the literal meaning of the words in a warning message, perceptions of the threat, alternative protective actions, and stakeholders involve broader associations that are integral parts of the schemas or mental models[31] within which the threat, protective actions, and stakeholders are embedded. It should be quite obvious that people will differ from each other in the comprehensiveness of their schemas about these objects. That is, some people will have highly differentiated schemas whereas others have poorly differentiated schemas about an object.

3.2.1. Perceptions of Environmental Threats

The essential attributes of people's perceptions of environmental threats are generally considered to be probability and consequences, but some well-known approaches to perceived risk include factors such as dread and unknown risks.[32] These additional dimensions of perceived risk appear to be useful in explaining people's responses to a broad range of technologies and societal activities, but it is not completely obvious how they are related to the perception of, and response to, imminent threats from environmental hazards.[33] Research on hazards and disasters has emphasized a definition of

perceived risk in terms of people's expectations of the personal impacts from an extreme environmental event.[7,8] These expected personal impacts include death, injury, property damage, and disruption to daily activities such as work, school, and shopping.[34] Moreover, most research on hazards and disasters has found that risk perception predicts warning responses such as evacuation[35] and long-term hazard adjustments.[36] These protective responses have been studied for hazards such as earthquakes,[37] hurricanes and other coastal storms,[38] floods,[39] and volcanic eruptions.[40] However, there have been some studies in which risk perception was unrelated to hazard adjustment.[34,40–42]

In addition to the certainty and severity of the expected personal impacts, environmental threats can differ in their degree of intrusiveness, which is the frequency of "thoughts generated by the distinctive hazard-relevant associations that people have with everyday events, informal hazard-relevant discussions with peers, and hazard-relevant information received passively from the media" (Ref. 13, p. 125). Hazard intrusiveness is correlated with the adoption of earthquake hazard adjustments[34,41] and expectations of participating in hurricane mitigation incentive programs.[43]

Expected personal impacts and hazard intrusiveness are related to the recency, frequency, and intensity of people's personal experience with hazard events.[34,43–45] Such experience can involve casualties or damage experienced by the respondent him/herself, by members of the immediate or extended family, or by friends, neighbors, or coworkers.[34] In turn, hazard experience is often correlated with proximity to earthquake,[46] hurricane,[47] and flood[48] sources. In addition to the indirect effect of hazard proximity on risk perception (via hazard experience), there can also be a direct relation between hazard proximity and perceived personal risk that is determined by a perceived risk gradient relating increasing proximity to increased risk.[49] However, the resulting risk judgments can be quite inaccurate because there are cases in which people have limited ability to identify their location in risk areas.[50,51]

Information from environmental cues and social warnings, together with prior beliefs about the hazard agent, produces a situational perception of personal risk that is characterized by beliefs about the ways in which environmental conditions will produce specific personal impacts. In hurricanes, for example, risk perceptions have been characterized by people's beliefs about the degree to which storm surge, inland flooding, and storm wind will cause their death or injury, kill or injure their loved ones, destroy their property, or disrupt their jobs or basic services such as electric power and water.[25,38]

3.2.2. Perceptions of Hazard Adjustments

A substantial amount of research has focused on people's perceptions of natural hazards but there is also a need for studying their perceptions of natural hazard adjustments.[52] Such studies are needed because the theory of reasoned action (TRA) posits that one's attitude toward an object (e.g., seismic hazard) is less predictive of behavior than one's attitude toward an act (seismic hazard adjustments) relevant to that object.[53] Thus, to understand the adoption of hazard adjustments, it is just as important to understand the perceived attributes of the hazard adjustments as the perceived attributes of the hazard itself.

The identity of these perceived attributes can be surmised from studies on the adoption of hazard adjustments, which have found support for attributes such as effectiveness,[54] cost,[55] required knowledge,[56] and utility for other purposes.[57] Lindell and Perry[5,13,52] summarized this line of research by proposing that hazard adjustments can be defined by hazard-related and resource-related attributes, both of which differentiate among hazard adjustments.[58] Hazard-related attributes, such as efficacy in protecting people and property and usefulness for other purposes, have been found to be significantly correlated with adoption intention and actual adjustment.[41,59,60] Resource-related attributes (cost, knowledge and skill requirements, time requirements, effort requirements, and required cooperation with others) generally have the predicted negative correlations with both adoption intention and actual adjustment, but these have been small and nonsignificant in studies conducted to date. The hazard adjustments in these studies have generally had small resource requirements, so it is unclear if the lack of support for the significance of these attributes is due to this factor.[58]

3.2.3. Perceptions of Social Stakeholders

Previous research has characterized stakeholders as authorities (federal, state, and local government), evaluators (scientists, medical professionals, universities), watchdogs (news media, citizens', and environmental groups), industry/employers, and households.[2,61,62] The interrelationships among stakeholders can be defined by their power over

each other's decisions to adopt hazard adjustments. French and Raven posited that power relationships can be defined in terms of six bases—reward, coercive, expert, information, referent, and legitimate power.[63,64] Reward and coercive power are the principal bases of regulatory approaches, but these require continuing surveillance to ensure rewards are received only for compliance and that punishment will inevitably follow noncompliance.[65] Such surveillance is rarely feasible, so authorities need to rely on bases of power other than reward and coercion. French and Raven's conceptions of expert (i.e., understanding of cause and effect relationships in the environment) and information (i.e., knowledge about states of the environment) power suggest assessing perceptions of stakeholders' hazard expertise. French and Raven's conception of referent power is defined by a person's sense of shared identity with another,[66] which is related to that person's trustworthiness. Although trust has been defined many different ways,[67] fairness, unbiasedness, willingness to tell the whole story, and accuracy are central.[68]

French and Raven defined legitimate power by the rights and responsibilities associated with each role in a social network, which raises questions about what households consider to be the responsibility of different stakeholders for protecting them from seismic hazard.[63] This is reinforced by research on stakeholders' perceived protection responsibility, which dates from research that attributed low rates of seismic adjustment adoption to respondents' beliefs that the federal government was the stakeholder most responsible for coping with earthquakes.[69] Much later, respondents had come to believe earthquake preparedness was an individual's responsibility.[70] The conclusion that a perception of personal protection responsibility leads to a higher level of seismic adjustment adoption is supported by similar findings on tornado adjustment adoption.[71] Recent research has found that stakeholders differ significantly in these perceived characteristics (expertise, trustworthiness, and protection responsibility) and, moreover, these characteristics have significant positive correlations with hazard adjustment intentions and actual adjustment adoption.[41,67]

3.3. Protective Action Decision Making

Once the three predecisional processes have been completed and the three types of core perceptions have been activated, cognitive processing turns to the series of decision stages—risk identification, risk assessment, protective action search, protective action assessment, and protective action implementation. In addition, information-seeking activities include information needs assessment, communication action assessment, and communication action implementation. Each of the decision stages in the PADM is discussed in detail below.

3.3.1. Risk Identification

According to the PADM, people's threat perceptions lead to risk identification, which is equivalent to what Lazarus and Folkman call primary appraisal.[72] In both emergency response and long-term hazard adjustment, those at risk must answer the basic question of risk identification: "Is there a real threat that I need to pay attention to?"[4,73,74] The importance of the resulting threat belief is supported by research showing individuals routinely try to maintain their definition of the environment as "normal" in the face of evidence that it is not.[2] Researchers have found a positive relationship between level of threat belief and disaster response across a wide range of disaster agents, including floods,[9,73] volcanic eruptions,[15,75] hazardous materials emergencies,[5] hurricanes,[25] earthquakes,[76] and nuclear power plant emergencies.[77,78]

3.3.2. Risk Assessment

The next step, risk assessment, refers to the process of determining expected personal impacts that a disaster could cause.[8,74] The process of assessing personal relevance has also been recognized as an important factor by persuasion theorists.[66] In the risk assessment stage, a positive response to the question "Do I need to take protective action?" elicits protection motivation whether the risk involves a disaster response or long-term hazard adjustment.[79,80] Some of the factors associated with people's personalization of risk include "the probability of the impending event occurring [and] the severity, to the individual, of such a development" (Ref. 81, p. 104).

As this quote indicates, the immediacy of a threat is important because warning recipients must understand that the message describes an event whose consequences are likely to occur in the very near future. Thus, immediacy is related to forewarning, which is the amount of time between the arrival of a warning (or personal detection of environmental cues) and disaster onset. People tend to engage in

activities such as information seeking and expedient property protection when they believe there is more time before impact than the minimum necessary to implement protective action.[9,82] Successful warning confirmation can ultimately increase compliance with recommended protective actions but does, inherently, delay them. Similarly, the amount of time that risk area residents devote to expedient property protection also delays their initiation of personal protective action. In both cases, the delay in protective action might be dangerous because the time of disaster impact cannot be predicted with perfect accuracy.[83]

3.3.3. Protective Action Search

If a threat is judged to be real and some unacceptable level of personal risk exists, people are motivated to engage in protective action search—which involves retrieving one or more feasible protective actions from memory or obtaining information about them from others. The relevant question in protective action search is "What can be done to achieve protection?" and its outcome is a decision set that identifies possible protective actions. In many instances, an individual's own knowledge of the hazard will suggest what type of protection to seek (e.g., evacuation from floods or sheltering in the basement from a tornado).

In addition, those in the risk area might become aware of feasible protective actions by observing social cues such as the behavior of others. This occurs, for example, when neighbors are seen packing cars in preparation for hurricane evacuation.[84] People also are likely to consider actions with which they have had vicarious experience by reading or hearing about others' protective actions. Such vicarious experience is frequently transmitted by the news media and relayed by peers. Finally, people also are made aware of appropriate protective actions by means of disaster warnings and hazard awareness programs that carry protective action recommendations from authorities. Specifically, a well-designed warning message will assist recipients by providing guidance in the form of one or more protective action recommendations.[8] However, such guidance is often inadequate. For example, water contamination advisories often suggest boiling drinking water, but fail to explain whether boiled water is also required for making ice, brushing teeth, rinsing vegetables, brewing coffee, cooking pasta, taking showers, or washing dishes, counters, hands, or clothes. They also frequently fail to mention other protective actions such as chlorinating the water or using bottled water.[85]

3.3.4. Protective Action Assessment

After people have established that at least one protective action is available, they pass from protective action search to the protective action assessment stage. This involves examining alternative actions, evaluating them in comparison to the consequences of continuing normal activities, and determining which of them is the most suitable response to the situation. At this point, the primary question is "What is the best method of protection?" and its outcome is an adaptive plan.

Choice is an inherent aspect of emergencies because those at risk generally have at least two options—taking protective action or continuing normal activities. Comparing alternatives with respect to their attributes leads, in turn, to a balancing or tradeoff of these attributes with respect to their relative importance to the decisionmaker. Under some conditions, those at risk can only take one action and, therefore, must make a choice among the alternatives (e.g., either evacuate or shelter in-place; Ref. 5, p. 155). In other cases, people can take multiple actions and must choose which ones to implement first. For example, people in earthquake prone areas are advised to have a working transistor radio with spare batteries, at least 4 gallons of water in plastic containers, a complete first-aid kit, and a 4-day supply of dehydrated or canned food for themselves and their families. They are also advised to strap water heaters, tall furniture, and heavy objects to the building walls and to bolt the house to its foundation.[57]

The end result of protective action assessment is an adaptive plan, but people's adaptive plans vary widely in their specificity, with some being only vague goals and others begin extremely detailed. At minimum, a specific evacuation plan includes a destination, a route of travel, and a means of transportation.[9] More detailed plans include a procedure for reuniting families if members are separated, advance contact to confirm the destination is available, consideration of alternative routes if the primary route is unsafe or too crowded, and alternative methods of transportation if the primary one is not available.[86]

3.3.5. Protective Action Implementation

The fifth step, protective action implementation, occurs when all the previous questions about risk reduction have been answered satisfactorily. In

general, the implementation of protective actions consumes resources people would prefer to allocate to other activities, so those at risk frequently delay implementation until they have determined that the immediacy of the threat justifies the disruption of normal activities. Thus, people often ask the question: "Does protective action need to be taken now?" The answer to this question, whose outcome is the threat response, is crucial because people sometimes postpone the implementation of protective action even when there is imminent danger. As noted earlier, recipients of hurricane warnings have often been found to endanger their safety because many wait until the last minute to begin their evacuations.[82,87] Unfortunately, they fail to recognize that adverse weather conditions and a high volume of traffic can significantly reduce the average speed of evacuating vehicles, thus running the risk that their evacuation will not be completed before the arrival of storm conditions.[25,88–90] The problem of procrastination is even more severe in connection with long-term hazard adjustment than it is in disasters with ample forewarning because hazard awareness programs cannot specify even an approximate deadline by which action must be taken. For example, an earthquake prediction might only be able to indicate a 67% chance of a damaging earthquake within the next 30 years.[91]

3.3.6. Information Needs Assessment

At any stage of the protective action decision process, some of the people who receive a warning might find that the available information is insufficient to justify a resource-intensive protective action. When they think time is available, people cope with the lack of information by searching for additional information.[9,15,92] The process of information search begins with an information needs assessment arising from an individual's judgment that the available information is insufficient to justify proceeding further in the protective action decision process. Thus, if any of the questions cannot be answered with an unequivocal yes or no, people will ask "What information do I need to answer my question?" so they can generate an identified information need. People commonly need additional information about the certainty, severity, and immediacy of the threat, and logistical support for protective action such as suitable evacuation routes, destinations, modes of transportation, and arrangements for pets and family members with major medical needs.

3.3.7. Communication Action Assessment

Identification of an information need does not necessarily suggest where the needed information can be obtained. Thus, the next question in the information seeking process is: "Where and how can I obtain this information?" Addressing this question leads to information source selection and information channel selection, which constitute an information search plan. The sources sought are likely to be affected by the available channels, which in many disasters precludes the use of the telephone because circuits are so overloaded that it is impossible to obtain a dial tone for hours or even days.[93] Further, attempts to reach authorities sometimes prove futile because emergency response agencies are busy handling other calls. Thus, people are often forced to rely on the mass media and peers—especially for information about protective actions.[94] This distinction between risk area residents' preferred channels of information receipt and their actual channels of information receipt also can be seen in connection with long-term hazard adjustment. For example, residents of communities downstream from the Mt. St. Helens volcano revealed some significant disparities between their preferred and actual channels of information receipt in the years after the 1980 eruptions.[5] Moreover, there also were significant differences between the two communities of Toutle and Lexington in both their preferred and actual channels of information receipt.

3.3.8. Communication Action Implementation

The final step in the information search process is communication action implementation, which provides decision information by answering the question: "Do I need the information now?" If the answer to this question is positive, that is, they are threatened by an imminent disaster, people will actively seek the needed information from the most appropriate source through the most appropriate channel. People will go to great lengths, contacting many people over a period of minutes to hours, if the prospect of an imminent disaster needs to be confirmed.[93,95] Indeed, half of the respondents in one study reported monitoring the news media hourly or more frequently.[96] However, information seeking will be less frequent and less active if the location is specific but the time of impact is ambiguous. Many residents of the area around Mt. St. Helens monitored the radio four or more times a day after the initial ash and

steam eruptions.[97] By contrast, the absence of locational specificity and time pressure inherent in a hazard awareness program provides little need for those at risk to obtain immediate answers, so they are likely to forego active information seeking in favor of passive monitoring of the situation. Unfortunately, the absence of a deadline for action means this passive monitoring is likely to continue until an imminent threat arises (as in the case of hurricanes and floods) or until a disaster strikes (as in the case of earthquakes).

4. SITUATIONAL IMPEDIMENTS AND FACILITATORS

The actual implementation of behavioral response depends not only on people's intentions to take those actions but also on conditions in their physical and social environment that can impede actions that they intended to take or that can facilitate actions that they did not intend to take.[98] In most cases, the lack of correspondence between intentions and behavior seems to be caused by impediments rather than unexpected facilitators; there are many instances in which people have wanted to evacuate but lacked a safe place to go and a safe route to travel.[9] Other impediments include a lack of access to a personal vehicle (e.g., those who are routinely transit dependent or families in which one spouse has the only car during the workday) or a lack of personal mobility due to physical disabilities.[99,100] In cases involving rapid onset disasters, the separation of family members can also be an evacuation impediment. Until family members have been reunited or separated family members can establish communication contact and agree upon a place to meet, evacuation is unlikely to occur.[101,102]

5. FEEDBACK

The final stage in the PADM is a feedback loop directed by the communication action assessment that returns to the initial inputs—environmental and social cues, and information sources, channel access and preferences, and warning messages. This feedback loop is extremely common in sudden onset disasters because people seek to confirm or contradict any warnings they have received, typically by contacting a different source using a different channel.[9] Alternatively, some people might be looking to obtain additional information about the threat, about which protective action to select, or about how to implement a protective action that they have selected. Finally, people might relay warnings to others or discuss the implications of the information they have received.[2] As is the case with the adoption of long-term hazard adjustments, a perceived lack of urgency in obtaining information about a hazard or protective actions can lead to procrastination.

6. THEORETICAL ASSESSMENT OF THE PADM

As the previous sections indicate, there has been a substantial amount of research that has been conducted within the framework of the PADM or on variables that are part of the PADM (e.g., other research on the relationship of risk perception to evacuation). In addition, there has been some limited discussion of the relationship between the PADM and the findings from research in domains other than hazards and disasters—including persuasion, social conformity, behavioral decision theory, attitude-behavior theory, and information seeking. However, there has only been limited discussion of the PADM in relation to other theories of protective action.

6.1. PADM Comparison to Other Theories of Protective Action

The PADM identifies a series of information-processing stages relevant to household adoption of protective actions and—for each stage—the typical activity performed, question asked, and outcome. The characterization of the PADM as a stage model of protective action warrants a comment in light of Weinstein, Rothman, and Sutton's critique of stage models of health behavior.[103] Like Janis and Mann's[4] conflict model, the PADM differs from stage models such as the Transtheoretical Model (TTM)[104] and the Precaution Adoption Process Model (PAPM)[105] in three important ways. First, risk area residents implement emergency response actions such as evacuation and sheltering in-place temporarily rather than permanently. Thus, the PADM lacks an equivalent to the TTM's maintenance stage and the idea of a "termination stage" has a qualitatively different meaning for the situations addressed by the PADM. In the TTM, termination is "the stage at which individuals have zero temptation"[104] to revert to their previous behavior. Thus, the TTM is clearly directed toward (health) behaviors that must be maintained indefinitely through continuing effort. In the PADM, by contrast,

"termination" of an inherently temporary emergency response would be the stage at which it is safe for individuals to revert to their previous ("normal") behavior.

Second, emergency response actions have significantly different time scales for their decision-making processes than do health behavior changes. During emergencies, people might pass through all of the stages of the PADM in a matter of minutes, whereas the TTM and PAPM address stages of change that are more likely to unfold over months or years. Finally, the PADM is typically applied to situations in which emergency managers are transmitting information concurrently to large numbers of people who are responding to a single "focusing event"[106] rather than situations in which health professionals conduct personal interventions that are tailored to individuals in different stages of a behavioral change process. Nonetheless, the PADM can be applied to long-term hazard adjustment as well as emergency response actions. In such cases as deciding to insure houses, elevate them above flood level, or bolt them to their foundations, there are more notable overlaps between the situations addressed by the PADM, on the one hand, and the TTM and PAPM, on the other hand. However, the extent of the overlap needs to be examined in future research.

In addition to examining the PADM's compatibility with stage models of health behavior, future research also needs to systematically examine its theoretical similarities to and differences from other psychological models. For example, hazard adjustment attributes in the PADM are equivalent to TRA's attitude toward the act. However, although disaster research has found that conformity with the behavior of others can be a significant influence on people's evacuation decisions, there has been no PADM research that has explicitly addressed the subjective norm as it has been conceptualized in the TRA. Moreover, the PADM's premise that people can vary in the extent to which they base their protective action decisions upon thoughtful consideration of information about environmental cues, social context, warning source characteristics, and warning message characteristics or, alternatively, upon unquestioning compliance with an authority's recommendation is similar to ideas about central versus peripheral routes to persuasion in the Elaboration Likelihood Model (ELM).[107] The findings of PADM research that are compatible with the ELM need to be replicated and extended.[41,67]

Finally, there are some similarities as well as distinct differences between PADM and protection motivation theory (PMT).[108–110] PADM's conception of hazard-related attributes (protection of persons, protection of property, and utility for other purposes) is similar to, but broader than, PMT's response efficacy. However, PADM's conception of resource-related attributes (cost, time and effort requirements, knowledge and skill, and required cooperation) is distinctly different from PMT's self-efficacy because the latter seems most closely related to the knowledge and skill component of the resource-related attributes. Moreover, the resource-related attributes are characteristics of a protective action whereas self-efficacy is a characteristic of the person. An advantage of the PADM formulation is that assessing the perceived characteristics of different protective actions makes it possible to determine if people have erroneous perceptions of the alternative actions and correct those misperceptions if they exist. In addition, identifying the characteristics of different protective actions makes it possible to identify which actions are most likely to be adopted and to initially focus a risk communication program on increasing their adoption. Once the most resource-effective hazard adjustments have been adopted (the ones that provide the greatest efficacy in protecting persons and property for a given level of resources), the risk communication program can be redirected toward the more resource-intensive hazard adjustments. Nonetheless, a focus on (personal) self-efficacy might be more useful than a focus on (task) resource requirements in some situations. For example, an emphasis on self-efficacy might be useful when one must implement a single protective action (e.g., weight loss) whereas a focus on task demands (resource requirements) might be more useful when someone can choose among multiple protective actions.

6.2. Identifying the Core Perceptions that Determine Protective Actions

One major implication of the literature cited in the previous section is that, despite extensive theorizing and data collection, it still is not entirely clear what motivates people to take protective action. One of the major contributions of PADM research is the finding that, though risk perception is usually an important determinant of protective action, there are other perceptions that are also important—and sometimes even more important than risk

perception. There is a need to consider other aspects of threat perception, such as hazard intrusiveness, and also to consider perceptions of protective actions and stakeholders. Nonetheless, it is not entirely clear whether the PADM's core perceptions of threat, protective actions, and stakeholders are themselves sufficient to account for an adequate percentage of the variance in people's hazard adjustment adoption.

This issue is particularly important when hazard experts, such as seismologists and earthquake engineers, try unsuccessfully to communicate event probabilities and consequences to risk area residents in an effort to increase the adoption of hazard adjustments. Lindell[111] addressed this problem by characterizing risk area residents' perceptions of three hazards (a volcanic eruption of Mt. St. Helens, a toxic chemical release from a railroad tank car, and a radiological materials release from a nearby nuclear power plant) in terms of four categories of hazard characteristics that were consistent with previous theorizing about technological hazards[32] and disaster impacts.[1] Respondents rated the three hazards in terms of hazard agent characteristics (likelihood of a major release, ease of risk reduction, and likelihood of release prevention), impact characteristics (speed of onset, existence of environmental cues, scope of impact, and duration of impact), expected personal impacts (immediate death, delayed cancer, genetic effects, and total property loss), and affective/behavioral reactions (dread, frequency of thought about the hazard, and frequency of discussion about the hazard). The results suggested that perceived impact characteristics mediated the relationship between characteristics of the hazard agent characteristics and expected personal impacts. Similar results emerged from a study of household evacuation decision making in response to Hurricane Ike.[84] Perceived storm characteristics (local landfall, major intensity, and rapid onset) partially mediated the effects of coastal proximity and hurricane experience on expected personal impacts (surge damage, inland flood damage, storm wind damage, and casualties), which, in turn, had a direct effect on evacuation decisions.

Another line of research that is likely to prove fruitful in understanding people's conceptions of hazards is the mental models approach.[31] Such studies interview individuals to elicit the elements of their beliefs about a specific hazard domain and the interrelationships among the elements of that domain. After interviewing a number of participants, the individual mental models can be aggregated into a consensus model. In a somewhat similar manner, the hazard beliefs approach[30,112] presents some very broad questions about a hazard to a pretest group, identifies common themes in the responses, and develops an inventory of fixed-response items that assess both accurate and erroneous beliefs. Both of these inductive approaches are likely to prove most useful in characterizing people's beliefs about new technologies such as nanotechnology.[113]

One of the major impediments to assessing how people think about hazards is that they vary in the differentiation of their beliefs about a domain and, among those with differentiated beliefs, there is variation in the degree to which those beliefs are integrated.[114] At one extreme are those who have few or no beliefs about the domain whereas, at the other extreme, are those who have highly differentiated belief systems characterized by a large number of elements that vary in the strength of their linkages.[115,116] Consistent with these analyses in other domains, there is evidence that risk area residents vary in the degree to which they have differentiated schemas or mental models of environmental hazards. This variation in people's hazard models has led some researchers to measure respondents' reactions to hazards simply in terms of a single questionnaire item of concern about the problem.[117] If risk area residents have only very diffuse conceptions of seismic threat, then a global construct such as concern might be a more accurate characterization of their beliefs than the specific dimensions assumed by PADM. Further research is needed to determine what proportions of the population have specific beliefs, global beliefs, and no beliefs at all about the environmental hazards to which they are exposed and the actions they can take to protect themselves.

7. PADM APPLICATIONS

The PADM has mostly been applied in three areas—risk communication programs, evacuation modeling, and long-term hazard adjustment. Each of these is discussed below.

7.1. PADM Application to Developing Community Risk Communication Programs

Research on which the PADM is based has led to the development of an extensive set of recommendations for risk communication, particularly in communities with ethnic minorities. These

recommendations for community risk communication programs are based upon the distinct differences between risk communication activities undertaken during the continuing hazard phase (the time between incidents) and those taken during an escalating crisis (when there is adequate forewarning of disaster impact) or emergency response (when forewarning is absent). Risk communication during the continuing hazard phase is directed toward encouraging long-term hazard adjustments such as hazard mitigation, emergency preparedness, and hazard insurance purchase. Risk communication during an escalating crisis or emergency response is directed toward encouraging appropriate disaster responses. However, risk communication during both phases requires the development of an effective risk communication program. Such programs need to be carefully developed during the continuing hazard phase because the human and financial resources available for environmental hazard management are usually limited until a crisis occurs. Although resources are more readily available during a crisis or emergency response, time is often severely limited so improvised efforts at risk communications can produce spectacular failures.[118]

There are five basic functions that should be addressed in the continuing hazard phase. These are strategic analysis, operational analysis, resource mobilization, program development, and program implementation (see Table I). The purpose of strategic analysis is to identify community constraints and set appropriate goals for the overall risk communication program. The purpose of operational analysis is to use the elements of the classic communication model (source, channel, message, receiver, effect, and feedback) to identify the community resources that are available for the risk communication program. The purpose of resource mobilization is to enlist the support of stakeholders in the community who are likely to share an interest in using risk communication to reduce hazard vulnerability. Program development for all phases involves the use of available community resources to develop a workable system that can implement risk communication in both the continuing hazard phase and also in an escalating crisis or emergency response. As soon as the risk communication program has been developed, it is possible to immediately begin program implementation for the continuing hazard phase. This function involves conducting the activities that will encourage risk area residents to adopt long-term hazard adjustments. It also involves conducting the activities that will allow authorities to determine if the risk communication program has been effective.

Table I. Tasks for the Continuing Hazard Phase

Strategic analysis
Conduct a community hazard/vulnerability analysis
Analyze the community context
Identify the community's prevailing perceptions of the hazards and hazard adjustments
Set appropriate goals for the risk communication program
Operational analysis
Identify and assess feasible hazard adjustments for the community and its households/businesses
Identify ways to provide incentives, sanctions, and technological innovations
Identify the available risk communication sources in the community
Identify the available risk communication channels in the community
Identify specific audience segments
Resource mobilization
Obtain the support of senior appointed and elected officials
Enlist the participation of other government agencies
Enlist the participation of nongovernmental (nonprofit) and private sector organizations
Work with the mass media
Work with neighborhood associations and service organizations
Program development for all phases
Staff, train, and exercise a crisis communications team
Establish procedures for maintaining an effective communication flow in an escalating crisis and in emergency response
Develop a comprehensive risk communication program
Plan to make use of informal communication networks
Establish procedures for obtaining feedback from the news media and the public
Program implementation for the continuing hazard phase
Build source credibility by increasing perceptions of expertise and trustworthiness
Use a variety of channels to disseminate hazard information
Describe community or facility hazard adjustments being planned or implemented
Describe feasible household hazard adjustments
Evaluate program effectiveness

Source: Lindell & Perry (2004).

The format of Table I might seem to imply that the five risk communication functions form a simple linear sequence, but some tasks will be performed concurrently and the entire process will frequently be iterative. For example, some resource mobilization tasks might take place concurrently with the operational analysis, or tasks conducted during the operational analysis phase might be suspended temporarily in order to return to the strategic analysis and refine it.

Once authorities have determined that they are in an escalating crisis or emergency response, they need to implement the predetermined risk communication actions that were developed during the continuing hazard phase. These include activating the crisis communication team promptly, determining the appropriate time to release sensitive information, and selecting the communication channels appropriate to the situation. An escalating crisis or emergency response also requires authorities to maintain source credibility with the news media and the public, provide timely and accurate information to the news media and the public, and evaluate performance through postincident critiques. For further details on the application of the PADM to the development of community risk communication programs, see Ref. 13, chapter 5.

7.2. PADM Application to Evacuation Models

Most of the research on the PADM and similar models has focused on the prediction of whether people will engage in a particular behavior. Although this is an important application, there are cases in which it is important to predict when people will engage in a particular behavior. For example, the timing of a household's evacuation departure is a critical input to transportation analysts' evacuation models because evacuation routes can become overloaded if too many vehicles enter the evacuation route system at the same time. Thus, local officials seeking to manage the evacuation need to understand the rate at which people receive an initial warning and the time it takes them to prepare to evacuate (see Refs. 119 and 120 for further discussion of evacuation time components). Each warning mechanism (siren, tone-alert radio, radio, television, and telephone) has a characteristic rate of exposure over time.[5,23,121] In addition, warning mechanisms vary in terms of their ability to attract attention and provide comprehensible messages that will change risk area residents' core perceptions of threat, protective actions, and stakeholders in the desired directions.

The time households spend in preparing to evacuate appears to involve two components, mental preparation and logistical preparation. Mental preparation is the time it takes to collect and process the information needed to decide an evacuation is necessary. The existence of a period of mental preparation has been documented in research indicating that people engage in milling, during which time they seek confirmation that a danger exists, obtain further information about the threat and alternative protective actions, and relay warnings to peers.[2] The broad outlines of this process are understood,[13,14,122] but there appears to be no research on the duration of psychological preparation for protective action.

Logistical preparation is the time it takes for a household to assemble the people and resources needed to implement protective action. Thus, evacuees need to perform tasks such as assembling family members, packing bags for the trip, and securing the house before leaving.[82] The time required for mental preparation and logistical preparation both contribute to total preparation time, but these components do not seem to be additive because the two components cannot be presumed to be mutually exclusive. That is, some household members might be searching for information at the same time that others are packing bags and still others installing hurricane shutters. Available evidence has documented that households' preparation times vary as a function of incident characteristics; for example, preparation times for evacuation from the Mt. St. Helens eruption were noticeably different from those for Hurricane Lili.[82] Because of these and other differences, predictions of evacuation departure times have been less successful than predictions of households' evacuation decisions. Some researchers have tried to improve prediction by adopting estimation models such as neural networks, sequential logit, and survival analysis but these have had modest success.[87,123–125]

Other research has extended the scope of the PADM to examine evacuation logistics—people's actions between the time they decide to evacuate and the time they arrive at their evacuation destinations[86] as well as the return entry process.[126] The latter process is, in some respects, just the reverse of the evacuation problem. However, it is more complicated because of the logistical problems authorities experience in communicating reentry information to evacuees that might be scattered over dozens of towns in multiple states.

7.3. PADM Application to Hazard Adjustment Adoption

A recent review of research on household adoption of hazard adjustments concluded that risk perception is consistently related to the adoption of hazard adjustments, but perceptions of stakeholders and hazard adjustments are also relevant and deserve greater attention.[36] There is considerable

evidence that hazard experience increases hazard adjustment adoption, but hazard proximity and hazard intrusiveness also appear to play significant roles and should be the focus of additional research. Finally, demographic variables continue to be unreliable predictors of hazard adjustment adoption but should receive continuing attention to assess their effects on risk perception, stakeholder perceptions, and hazard adjustment perceptions, as well as hazard experience, hazard proximity, and hazard intrusiveness.

One of the major limitations of hazards and disasters studies to date is that the PADM predicts that some of the variables should form causal chains. For example, hazard proximity is predicted to cause hazard experience, hazard experience is predicted to cause risk perception, and risk perception is predicted to cause hazard adjustment adoption. Another example is that perceptions of information sources' expertise, trustworthiness, and protection responsibility should affect risk area residents' risk perceptions, which, in turn, should affect their adoption of hazard adjustments. That is, each successive variable is hypothesized to completely mediate the relationship between the variable that precedes it and the variable that follows it so that, for example, the estimated effect of stakeholder perceptions on hazard adjustment adoption becomes nonsignificant when controlling for risk perception. Most hazards and disasters studies to date have used single equation models to predict a single dependent variable such as household hazard adjustment or evacuation so their results cannot shed any light on the mediation hypotheses. Moreover, the few studies that did report tests of the PADM's mediation hypotheses have found only partial mediation where complete mediation was expected.[34,44] Nonetheless, the results did suggest that risk area residents' awareness of the available hazard adjustments and accurate perceptions of their attributes do mediate the relationship between hazard experience and hazard adjustment.[59,127] In addition, Lindell and Prater found evidence that hazard intrusiveness had an effect on hazard adjustment adoption that was independent of perceived personal risk.[34]

In some cases, the failure of a complete mediation hypothesis has a theoretically logical explanation. For example, the inability of risk perception or hazard intrusiveness to completely mediate the relationship between perceived stakeholder characteristics and hazard adjustment adoption is consistent with Petty and Cacioppo's[128] distinction between central and peripheral routes to persuasion and Chaiken's[129] distinction between systematic and heuristic processes. Both theories assert that incidental factors such as stakeholder perceptions affect attitudes and behavior without affecting salient beliefs or subjective norms (to use terms from TRA). Further research is needed to determine if the failures to find complete mediation are due to additional variables specified by the PADM, other variables not specified by the PADM, or are simply manifestations of the effects of peripheral/heuristic processing.

8. CONCLUSION

This article has described an updated version of the PADM and summarized the research that supports its principal components. This review includes articles that were cited in Lindell and Perry,[13] but also includes other research conducted prior to and subsequent to that book's publication. There are varying degrees of support for different components of the PADM. Some components have extensive support, whereas others have conflicting or counter-intuitive findings, and still others are largely untested. Future research should seek to resolve the conflicting findings, explain the counterintuitive findings, and examine the untested propositions.

In addition to its predictive validity, any theoretical model should be useful. Accordingly, this article has described the ways in which the PADM has been applied to three different areas—risk communication, evacuation modeling, and long-term hazard adjustment. Although these applications are in their early stages, the evidence to date suggests that the PADM is continuing to evolve into a useful framework for managing societal response to environmental hazards. Applications of the model would not need to produce large changes in behavior to be valuable. Updating an argument made in an earlier article,[41] major disasters are so costly—the economic impact of Hurricane Katrina was estimated to range from $81 billion[130] to $140 billion[131]—that even a 1% decrease in losses would save hundreds of millions if not billions of dollars.

ACKNOWLEDGMENTS

This work was supported by the National Science Foundation under Grants SES 0527699, SES 0838654, and CMM 0927739. None of the conclusions expressed here necessarily reflects views other than those of the authors.

REFERENCES

1. Barton A. Communities in Disaster. New York: Doubleday, 1969.
2. Drabek TE. Human System Responses to Disaster: An Inventory of Sociological Findings. New York: Springer-Verlag, 1986.
3. Fritz CE. Disaster. In Merton RK, Nisbet RA (eds). Contemporary Social Problems. New York: Harcourt, Brace & World, 1961.
4. Janis I, Mann L. Decision Making: A Psychological Analysis of Conflict, Choice and Commitment. New York: Free Press, 1977.
5. Lindell MK, Perry RW. Behavioral Foundations of Community Emergency Planning. Washington, DC: Hemisphere Press, 1992.
6. Mileti DS, Drabek T, Haas JE. Human Systems in Extreme Environments. Boulder, CO: University of Colorado Institute of Behavioral Science, 1975.
7. Mileti DS, Peek L. The social psychology of public response to warnings of a nuclear power plant accident. Journal of Hazardous Materials, 2000; 75:181–194.
8. Mileti, D S, Sorensen JH. Why people take precautions against natural disasters. Pp. 296–320 in Weinstein N (ed). Taking Care: Why People Take Precautions. New York: Cambridge University Press, 1987.
9. Perry RW, Lindell MK, Greene MR. Evacuation Planning in Emergency Management. Lexington, MA: Heath Lexington Books, 1981.
10. Tierney K, Lindell, MK, Perry RW. Facing the Unexpected: Disaster Preparedness and Response in the United States. Washington, DC: Joseph Henry Press, 2001.
11. Burton I, Kates, R, White GF. The Environment as Hazard, 2nd edition. New York: Guildford Press, 1993.
12. Lindell MK, Alesch D, Bolton PA, Greene MR, Larson LA, Lopes R, May PJ, Mulilis J-P, Nathe S, Nigg JM, Palm R, Pate P, Perry RW, Pine J, Tubbesing SK, Whitney DJ. Adoption and implementation of hazard adjustments. International Journal of Mass Emergencies and Disasters Special Issue, 1997; 15:327–453. Available at: www.ijmed.org, Accessed 1 May 2010.
13. Lindell MK, Perry RW. Communicating Environmental Risk in Multiethnic Communities. Thousand Oaks, CA: Sage, 2004.
14. Gladwin CH, Gladwin H, Peacock WG. Modeling hurricane evacuation decisions with ethnographic methods. International Journal of Mass Emergencies and Disasters, 2001; 19:117–143. Available at: www.ijmed.org, Accessed 1 May 2010.
15. Perry RW, Greene, M. Citizen Response to Volcanic Eruptions. New York: Irvington, 1983.
16. Lindell MK, Prater CS, Perry RW. Fundamentals of Emergency Management. Emmitsburg, MD: Federal Emergency Management Agency Emergency Management Institute, 2006. Available at: www.training.fema.gov/EMIWeb/edu/fem.asp, Accessed 1 May 2010.
17. Lasswell H. The structure and function of communication in society. Pp. 43–71 in Bryson L (ed). Communication of Ideas. New York: Harper, 1948.
18. McGuire WJ. The nature of attitudes and attitude change. Pp. 329–334 in Lindsey G, Aronson E (eds). Handbook of Social Psychology, 2nd edition. Reading, MA: Addison-Wesley, 1969.
19. McGuire WJ. The nature of attitudes and attitude change. Pp. 233–256 in Lindsey G, Aronson E (eds). Handbook of Social Psychology, 3rd edition. New York: Random House, 1985.
20. O'Keefe D. Persuasion: Theory and Research, 2nd edition. Thousand Oaks, CA: Sage, 2002.
21. Petty RE, Wegener DT. Attitude change: Multiple roles for persuasion variables. Pp. 323–390 in Gilbert DT, Fiske ST, Lindzey G (eds). Handbook of Social Psychology, 4th edition. New York: McGraw-Hill, 1998.
22. Lindell MK, Prater CS, Peacock WG. Organizational communication and decision making in hurricane emergencies. Natural Hazards Review, 2007; 8:50–60.
23. Rogers GO, Sorensen JH. Diffusion of emergency warnings. Environmental Professional, 1988; 10:185–198.
24. Aguirre BE. The lack of warnings before the Saragosa tornado. International Journal of Mass Emergencies and Disasters, 1988; 6:65–74. Available at: www.ijmed.org, Accessed 1 May 2010.
25. Baker EJ. Hurricane evacuation behavior. International Journal of Mass Emergencies and Disasters, 1991; 9:287–310. Available at: www.ijmed.org, Accessed 1 May 2010.
26. Fiske ST, Taylor SE. Social Cognition: From Brains to Culture. Boston: McGraw-Hill, 2008.
27. Committee on Disaster Research in the Social Sciences. Facing Hazards and Disasters: Understanding Human Dimensions. Washington, DC: National Academy of Sciences/National Research Council, 2006.
28. Mayhorn CB. Cognitive aging and the processing of hazard information and disaster warnings. Natural Hazards Review, 2005; 6:165–170.
29. Lindell MK, Prater CS. Tsunami preparedness on the Oregon and Washington coast: Recommendations for research. Natural Hazards Review, 2010; 11:69–81.
30. Turner R, Nigg J, Heller-Paz D. Waiting for Disaster. Los Angeles: University of California Press, 1986.
31. Morgan MG, Fischhoff B, Bostrom A, Atman CJ. Risk Communication: A Mental Models Approach. Cambridge: Cambridge University Press, 2002.
32. Slovic P, Fischhoff B, Lichtenstein S. How safe is safe enough: A psychometric study of attitudes toward technological risks and benefits. Pp. 80–103 in Slovic P (ed). The Perception of Risk. London: Earthscan, 1980.
33. Terpstra T, Lindell MK, Gutteling JM. Does communicating (flood) risk affect (flood) risk perceptions? Results of a quasi-experimental study. Risk Analysis, 2009; 29:1141–1155.
34. Lindell MK, Prater CS. Household adoption of seismic hazard adjustments: A comparison of residents in two states. International Journal of Mass Emergencies and Disasters, 2000; 18:317–338. Available at: www.ijmed.org, Accessed 1 May 2010.
35. Sorensen JH. Hazard warning systems: Review of 20 years of progress. Natural Hazards Review, 2000; 1:119–125.
36. Lindell MK. North American cities at risk: Household responses to environmental hazards. In. Rossetto T, Joffe H, Adams J (eds). Cities at Risk: Living with Perils in the 21st Century. Dordrecht: Springer, in press.
37. Mileti DS, Fitzpatrick C. The causal sequence of risk communication in the Parkfield earthquake prediction experiment. Risk Analysis, 1992; 12:393–400.
38. Dash N, Gladwin H. Evacuation decision making and behavioral responses: Individual and household. Natural Hazards Review, 2007; 8:69–77.
39. Terpstra T, Gutteling JM. Households' perceived responsibilities in flood risk management in the Netherlands. International Journal of Water Resources Development, 2008; 24:555–565.
40. Perry RW, Lindell MK. Volcanic risk perception and adjustment in a multi-hazard environment. Journal of Volcanology and Geothermal Research, 2008; 172:170–178.
41. Lindell MK, Whitney DJ. Correlates of seismic hazard adjustment adoption. Risk Analysis, 2000; 20:13–25.
42. Mileti DS, Darlington JD. The role of searching in shaping reactions to earthquake risk information. Social Problems, 1997; 44:89–103.

43. Ge Y, Peacock WG, Lindell MK. Florida households' expected responses to hurricane hazard mitigation incentives. Risk Analysis, in press.
44. Lindell MK, Hwang SN. Households' perceived personal risk and responses in a multi-hazard environment. Risk Analysis, 2008; 28:539–556.
45. Weinstein ND. Effects of personal experience on self-protective behavior. Psychological Bulletin, 1989; 105:31–50.
46. Palm R, Hodgson M, Blanchard, RD, Lyons D. Earthquake Insurance in California. Boulder, CO: Westview Press, 1990.
47. Peacock WG, Brody SD, Highfield W. Hurricane risk perceptions among Florida's single family homeowners. Landscape and Urban Planning, 2005; 73:120–135.
48. Preston V, Taylor SM, Hedge DC. Adjustment to natural and technological hazards: A study of an urban residential community. Environment and Behavior, 1983; 15:143–164.
49. Lindell MK, Earle TC. How close is close enough: Public perceptions of the risks of industrial facilities. Risk Analysis, 1983; 3:245–253.
50. Arlikatti S, Lindell MK, Prater CS, Zhang Y. Risk area accuracy and hurricane evacuation expectations of coastal residents. Environment and Behavior, 2006; 38:226–247.
51. Zhang Y, Prater CS, Lindell MK. Risk area accuracy and evacuation from Hurricane Bret. Natural Hazards Review, 2004; 5:115–120.
52. Lindell MK, Perry RW. Household adjustment to earthquake hazard: A review of research. Environment and Behavior, 2000; 32:590–630.
53. Fishbein MF, Ajzen I. Predicting and Changing Behavior: The Reasoned Action Approach. New York: Psychology Press, 2010.
54. Mulilis J-P, Duval TS. Negative threat appeals and earthquake preparedness: A person-relative-to-event PrE model of coping with threat. Journal of Applied Social Psychology, 1995; 25:1319–1339.
55. Kunreuther H, Ginsberg R, Miller L, Sagi P, Slovic P, Borkan B, Katz N. Disaster Insurance Protection: Public Policy Lessons. New York: John Wiley, 1978.
56. Davis MS. Living along the fault line: An update on earthquake awareness and preparedness in Southern California. Urban Resources, 1989; 5:8–14.
57. Russell L, Goltz JD, Bourque LB. Preparedness and hazard mitigation actions before and after two earthquakes. Environment and Behavior, 1995; 27:744–770.
58. Lindell MK, Arlikatti S, Prater CS. Why people do what they do to protect against earthquake risk: Perceptions of hazard adjustment attributes. Risk Analysis, 2009; 29:1072–1088.
59. Lindell MK, Prater CS. Risk area residents' perceptions and adoption of seismic hazard adjustments. Journal of Applied Social Psychology, 2002; 32:2377–2392.
60. Terpstra T, Lindell MK. Citizens' Perceptions of Flood Hazard Adjustments: An Application of the Protective Action Decision Model. College Station, TX: Texas A&M University Hazard Reduction & Recovery Center, 2009.
61. Pijawka KD, Mushkatel AH. Public opposition to the siting of the high-level nuclear waste repository: The importance of trust. Policy Studies Review, 1991; 10:180–194.
62. Lang JT, Hallman WK. Who does the public trust? The case of genetically modified food in the United States. Risk Analysis, 2005, 25:1241–1252.
63. French JRP, Raven BH. The bases of social power. Pp. 150–167 in Cartwright D (ed). Studies in Social Power. Ann Arbor, MI: Institute for Social Research, 1959.
64. Raven B. Social influence and power. Pp. 371–382 in Steiner I, Fishbein M (eds). Current Studies in Social Psychology. New York: Holt, Rinehart & Winston, 1965.
65. Raven BH. The bases of power: Origins and recent developments. Journal of Social Issues, 1993; 49:227–251.
66. Eagly AH, Chaiken S. The Psychology of Attitudes. Ft. Worth, TX: Harcourt, Brace College Publishers, 1993.
67. Arlikatti S, Lindell MK, Prater CS. Perceived stakeholder role relationships and adoption of seismic hazard adjustments. International Journal of Mass Emergencies and Disasters, 2007; 25:218–256. Available at: www.ijmed.org, Accessed 1 May 2010.
68. Meyer P. Defining and measuring credibility of newspapers: Developing an index. Journalism Quarterly, 1988; 65:567–574, 588.
69. Jackson EL. Response to earthquake hazard: The West Coast of North America. Environment and Behavior, 1981; 13:387–416.
70. Garcia EM. Earthquake preparedness in California: A survey of Irvine residents. Urban Resources, 1989; 5:15–19.
71. Mulilis JP, Duval TS. The PrE model of coping with threat and tornado preparedness behavior: The moderating effects of felt responsibility. Journal of Applied Social Psychology, 1997; 27:1750–1766.
72. Lazarus RS, Folkman S. Stress, Appraisal, and Coping. New York: Springer, 1984.
73. Mileti DS. Natural hazards warning systems in the United States. Boulder, CO: University of Colorado Institute of Behavioral Science, 1975.
74. Perry RW. Evacuation decision making in natural disaster. Mass Emergencies, 1979; 4:25–38.
75. Perry RW, Hirose H. Volcano Management in the United States and Japan. Greenwich, CT: JAI Press, 1991.
76. Blanchard-Boehm RD. Understanding public response to increased risk from natural hazards. International Journal of Mass Emergencies and Disasters, 1998; 16:247–278. Available at: www.ijmed.org, Accessed 1 May 2010.
77. Houts PS, Cleary PD, Hu TW. The Three Mile Island Crisis: Psychological, Social and Economic Impacts on the Surrounding Population. University Park, PA: Pennsylvania State University Press, 1988.
78. Perry RW. Comprehensive Emergency Management: Evacuating Threatened Populations. Greenwich, CT: JAI, 1985.
79. Fritz CE, Marks, E. The NORC studies of human behavior in disaster. Journal of Social Issues, 1954; 10:26–41.
80. Perry RW. Environmental hazards and psychopathology. Environmental Management, 1983; 7:543–552.
81. Withey S. Reaction to uncertain threat. Pp. 93–123 in Baker G, Chapman D (eds). Man and Society in Disaster. New York: Basic Books, 1962.
82. Lindell MK, Lu JC, Prater CS. Household decision making and evacuation in response to Hurricane Lili. Natural Hazards Review, 2005; 6:171–179.
83. Lindell MK, Prater CS. A hurricane evacuation management decision support system (EMDSS). Natural Hazards, 2007; 40:627–634.
84. Huang SK, Lindell MK, Prater CS, Wu HC, Siebeneck LK. Household Evacuation Decision Making in Response to Hurricane Ike. College Station, TX: Texas A&M University Hazard Reduction & Recovery Center, 2010.
85. Lindell MK, Mumpower J, Huang S-K, Wu H-C. Perceptions and Expected Responses to a Water Contamination Emergency. College Station, TX: Texas A&M University Hazard Reduction & Recovery Center, 2010.
86. Lindell MK, Kang JE, Prater CS. The logistics of household evacuation in Hurricane Lili. Natural Hazards, in press.
87. Fu H, Wilmot CG, Zhang H, Baker EJ. Modeling the hurricane evacuation response curve. Transportation Research Record, 2007; 2022:94–102.
88. Baker EJ. Hurricane evacuation in the United States. Pp. 98–108 in Pielke R Jr, Pielke R Sr (eds). Storms, Vol .1. London: Routledge, 2000.

89. Dow K, Cutter SL. Crying wolf: Repeat responses to hurricane evacuation orders. Coastal Management, 1998; 26:237–252.
90. Dow K, Cutter SL. Emerging hurricane evacuation issues: Hurricane Floyd and South Carolina. Natural Hazards Review, 2002; 3:12–18.
91. Southern California Earthquake Center. Uniform California Earthquake Rupture Forecast (UCERF), 2011. Available at: www.scec.org/ucerf/, Accessed 27 January 2011.
92. Hanson S, Vitek JD, Hanson PO. Natural disaster: Long-range impact on human response to future disaster threats. Environment and Behavior, 1979; 11:268–284.
93. Drabek TE. Social processes in disaster: Family evacuation. Social Problems, 1969; 16:336–347.
94. Lindell MK, Perry RW. Risk area residents' changing perceptions of volcano hazard at Mt. St. Helens. Pp. 159–166 in Siccardi F, Nigg J, Nemec J (eds). Prediction and Perception of Natural Hazards. Amsterdam: Kluwer Academic Publishers, 1993.
95. Drabek TE, Stephenson J. When disaster strikes. Journal of Applied Social Psychology, 1971; 1:187–203.
96. Morss RE, Hayden MH. Storm surge and "certain death": Interviews with Texas coastal residents following Hurricane Ike. Weather, Climate, and Society, 2010; 2:174–189.
97. Perry RW, Lindell MK, Greene MR. Threat perception and public response to volcano hazard. Journal of Social Psychology, 1982; 116:199–204.
98. Triandis HC. Values, attitudes, and interpersonal behavior. Pp. 195–259 in Howe H, Page M (eds). Nebraska Symposium on Motivation, Vol. 27. Lincoln, NE: University of Nebraska Press, 1980.
99. Heath SE, Kass PH, Beck AM, Glickman LT. Human and pet-related risk factors for household evacuation failure during a natural disaster. American Journal of Epidemiology, 2001; 153;659–667.
100. Van Willigen M, Edwards T, Edwards B, Hessee S. Riding out the storm: Experiences of the physically disabled during Hurricanes Bonnie, Dennis, and Floyd. Natural Hazards Review, 2002; 3:98–106.
101. Killian LM. The significance of multi-group membership in disaster. American Journal of Sociology, 1952; 57:309–314.
102. Drabek TE, Boggs K. Families in disaster: Reactions and relatives. Journal of Marriage and the Family, 1968; 30:443–451.
103. Weinstein ND, Rothman AJ, Sutton SR. Stage theories of health behavior: Conceptual and methodological issues. Health Psychology, 1998; 17:290–299.
104. Prochaska JO, Johnson S, Lee P. The transtheoretical model of behavior change. Pp. 59–84 in Gochman DS (ed). Handbook of Health Behavior Research I: Personal and Social Determinants. New York: Plenum Press, 1997.
105. Weinstein ND. The precaution adoption process. Health Psychology, 1988; 7:355–386.
106. Birkland TA. After Disaster: Agenda Setting, Public Policy and Focusing Events. Washington, DC: Georgetown University Press, 1997.
107. Petty RE, Wegener DT. The elaboration likelihood model: Current status and controversies. Pp. 37–72 in Chaiken, Trope Y (eds). Dual-Process Theories in Social Psychology. New York: Guilford Press, 1999.
108. Floyd DL, Prentice-Dunn S, Rogers RW. A meta-analysis of research on protection motivation theory. Journal of Applied Social Psychology, 2000; 30:407–429.
109. Neuwirth K, Dunwoody S, Griffin RJ. Protection motivation and risk communication. Risk Analysis, 2000; 20:721–734.
110. Rogers RW. A protection motivation theory of fear appeals and attitude change. Journal of Psychology, 1975; 91:93–114.
111. Lindell MK. Perceived characteristics of environmental hazards. International Journal of Mass Emergencies and Disasters, 1994; 12:303–326. Available at: www.ijmed.org, Accessed 1 May 2010.
112. Whitney DJ, Lindell MK, Nguyen DH. Earthquake beliefs and adoption of seismic hazard adjustments. Risk Analysis, 2004; 24:87–102.
113. Bostrom A, Lofstedt RE. Nanotechnology risk communication past and prologue. Risk Analysis, 2010; 30:1645–1662.
114. Scott WA, Osgood DW, Peterson C. Cognitive Structure: Theory and Measurement of Individual Differences. New York: Wiley, 1979.
115. Converse PE. The nature of belief systems in mass publics. Pp. 206–261 in Apter DE (ed). Ideology and Discontent. New York: Free Press, 1964.
116. Schuman H, Kalton G. Survey methods. Pp. 635–698 in Lindzey G, Aronson E (eds). The Handbook of Social Psychology, 3rd edition, Vol. 1. Reading, MA: Addison-Wesley, 1985.
117. Dooley D, Catalano R, Mishra S, Serxner S. Earthquake preparedness: Predictors in a community survey. Journal of Applied Social Psychology, 1992; 22:451–470.
118. Seeger MW, Sellnow TL, Ulmer RR. Communication and Organizational Crisis. Westport, CT: Praeger, 2003.
119. Lindell MK. EMBLEM2: An empirically based large-scale evacuation time estimate model. Transportation Research, 2008; A 42:140–154.
120. Lindell MK, Prater CS. Critical behavioral assumptions in evacuation analysis for private vehicles: Examples from hurricane research and planning. Journal of Urban Planning and Development, 2007; 133:18–29.
121. Lindell MK, Perry RW. Warning mechanisms in emergency response systems. International Journal of Mass Emergencies and Disasters, 1987; 5:137–153. Available at: www.ijmed.org, Accessed 1 May 2010.
122. Gladwin H, Peacock WG. Warning and evacuation: A night for hard houses. Pp. 52–74 in Peacock WG, Morrow BH, Gladwin H (eds). Hurricane Andrew: Gender, Ethnicity and the Sociology of Disasters. London: Routledge, 1997.
123. Dixit VV, Pande A, Radwan E, Abdel-Aty M. Understanding the impact of a recent hurricane on mobilization time during a subsequent hurricane. Transportation Research Record, 2008; 2041:49–57.
124. Fu H, Wilmot CG. Survival analysis–based dynamic travel demand models for hurricane evacuation. Transportation Research Record, 2006; 1964:211–218.
125. Wilmot CG, Mei B. Comparison of alternative trip generation models for hurricane evacuation. Natural Hazards Review, 2004; 5:170–178.
126. Siebeneck LK, Cova TJ. An assessment of the return-entry process for Hurricane Rita 2005. International Journal of Mass Emergencies and Disasters, 2008; 26:91–111. Available at: www.ijmed.org, Accessed 1 May 2010.
127. Norris FH, Smith T, Kaniasty K. Revisiting the experience-behavior hypothesis: The effects of Hurricane Hugo on hazard preparedness and other self-protective acts. Basic and Applied Social Psychology, 1999; 21:37–47.
128. Petty RE, Cacioppo JT. Communication and Persuasion: Central and Peripheral Routes to Attitude Change. New York: Springer-Verlag, 1986.
129. Chaiken S. The heuristic model of persuasion. Pp. 3–39 in Zanna MP, Olson JM, Herman CP (eds). Social Influence: The Ontario Symposium, Vol. 5. Hillsdale NJ: Erlbaum, 1987.
130. Knabb RD, Rhome JR, Brown DP. Tropical Cyclone Report: Hurricane Katrina 23–30 August 2005. Mimi, FL: National Hurricane Center, 2006. Available at: http://www.nhc.noaa.govpdf/TCR-AL122005_Katrina.pdf, Accessed 25 January 2011.
131. Burton L, Hicks MJ. Hurricane Katrina: Preliminary Estimates of Commercial and Public Sector Damages. Huntington, WV: Marshall University for Economic and Business Research, 2005. Available at: http://www.marshall.edu/cber/, Accessed 1 January 2011.