Communication of Emergency Warning: A Cyclical Process

by G. O. Rogers*

Conceptually, emergency warnings are cyclical. People and organisations face potential obstacles to effective communication as they enter the warning process. Because people are integral links in the warning process, technological warning systems alone are unlikely to disseminate warning effectively. For communication of emergency warning to be effective, people have to be integrated into the process.

Introduction

The Superfund Amendments and Reauthorisation Act in the USA requires public officials and firms using storing, or producing potentially hazardous chemicals to establish emergency warning systems. These systems are most frequently characterised in terms of the equipment used to transmit information – the channel of communication. This paper focuses on the people who are integral parts of the emergency warning system.

The efficacy of emergency warning depends on warning technology, the people operating it, and the responses of the people receiving the warning message. Warning systems integrate technology and people, each limiting and augmenting the other. As a result, a technological warning system can only be as effective as the people operating it, while the people are limited without the warning system technology.

The warning process repeatedly involves the interaction of technology and people in a cyclical and continuous process. It begins at various cycles for different people and organisations. Some parts of the process may also vary considerably in duration and complexity. Because different people enter the process at various cycles, they have different perspectives of the situation. For example, when workers at a hazardous facility become aware of the potentially harmful situation, in effect they have detected the hazard. They assess the initial potential for danger, communicate among themselves, and respond. One of these responses may include communicating the occurrence to facility management. In this situation, management becomes aware of the potential for harm, and for them, hazard detection has just occurred.

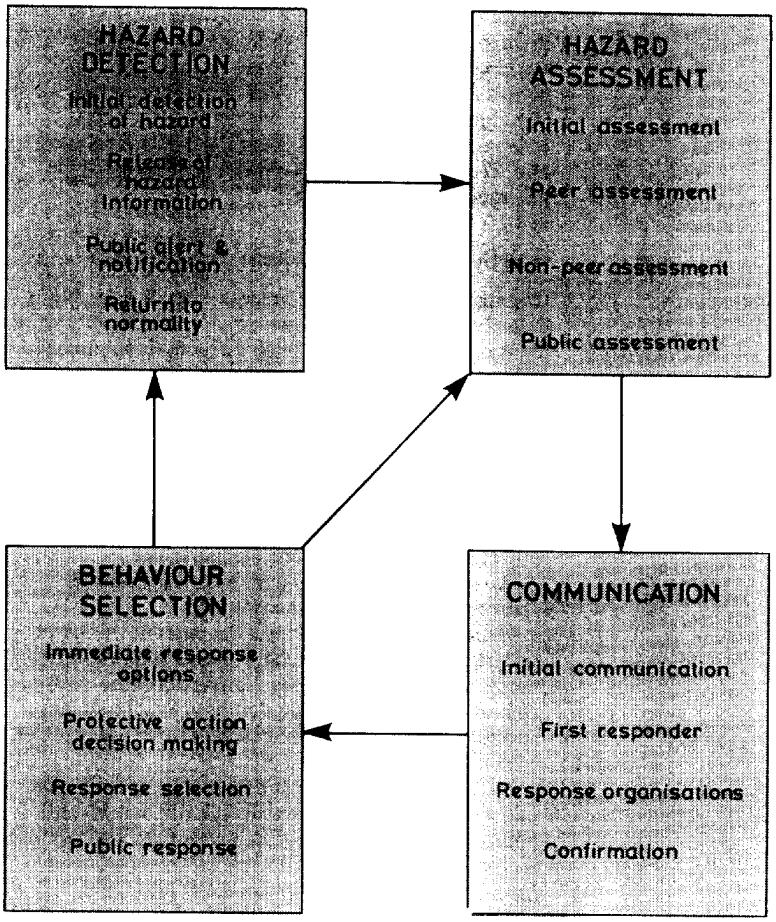
The warning process is cyclical in two fundamental ways:

1 As the emergency develops, the warning phases are repeated by people as they enter the process; each person beginning the cycle with some form of detection, and cycling through assessment, communication and behaviour selection.

2 Because emergencies are dynamic, the warning cycles through detection, assessment and re-assessment, communication, and behaviour selection processes in adjusting response(s) to the changing emergency situation.

Fig. 1 summarises the cyclical nature of emergency warnings.

1 A cyclical nature of warning.



People in the warning process itself can thwart its effectiveness. In one example, officials relayed information to the police department concerning the location and direction that a tornado was moving. The police were specifically asked to relay the information to the radio stations for public warning. However, this never took place[1, pp.21-22]. The police department,

> . . . apparently did not notify the local radio station nor any other organisation within the county. The [warning message] information died with the police. The Chief of Police was afraid that the people might panic unnecessarily if warned directly by them:
>
> My idea about warning is different from some people. . . . Some want to alert everybody (right) now.

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> An alert is all right, but it has the tendency to panic people a lot of times. . . . I think you should alert your first-aid centres, your CD, and things like this . . . but not the general public too much.
>
> I don't like to panic them. I know some people personally, that the minute there's a sign of a tornado or (that there) might be a tornado, . . . they panic right now[1, pp. 21-22].

People involved in emergency warning evaluate enormous quantities of information and must exercise human judgment. These judgments are based on a foundation of experience, values, and knowledge, that may contain faulty data, erroneous assumptions, or flawed logic. Such decision biases are reflected in the persistent myths about behaviour in emergencies, such as that concerning panic, which are not borne out by the evidence. People process warning messages in the context of their physical and social environments. They receive the message, establish its meaning based on a blend of its content and social context, and act on the basis of the modified message and how it stimulates them to respond. By establishing the meaning of the warning message in terms of experience, values, and knowledge, the potential for erroneous judgment is introduced. Because people process information received, it is imperative that warning systems recognise and account for these human factors imbedded in the emergency warning system.

The Cyclical Warning Process

Because some parts of the process vary considerably in complexity and duration, some cycles may be eliminated or skipped. The cyclical warning process is comprised of four interdependent phases:

a Hazard detection always initiates the cycle by signalling the potential for harm;
b hazard assessment examines the potential for harm to determine the extent of danger;
c hazard communication involves transmitting that information to others as well as receiving feedback from others regarding the potential dangers; and
d the selection of behaviour involves determining appropriate responses to the situation.

Hazard detection recognises the potential for harm and triggers an evaluation; hazard assessment analyses the situation and determines the severity of the hazard, communication disseminates or discusses the situation and course of action; and selection of behaviour decides what to do.

Hazard detection initiates the warning process. The initial detection of the potential for harm may involve human senses or technological monitoring. No response is possible without hazard detection. There are two mechanisms by which people become aware of the potential for harm – one involves the interpretation of environmental clues, and the other involves communication from others. The interpretation of environmental clues involves both the direct sensation of hazard (e.g., seeing the river rise, smelling smoke, or feeling the tremors of an earthquake) or the technologically assisted detection of potential hazard (e.g., interpreting data provided by remote sensing devices and monitors, or hearing an alarm, or seeing a flashing light on a control panel). Events vary by the extent to which those people affected are involved in the interpretation of the environmental clues. When relatively few people are actually involved in the initial interpretation of the environmental clues, the focus of the warning process is on the centralised assessment and the communication of the warning. As the proportion of people detecting the hazard through environmental clues increases, hazard assessment and communication are decentralised. For example, warning messages may be more easily believable, and therefore, reduce or eliminate some of the obstacles to communication.

Once people become aware of the potential for harm, hazard assessment evaluates the extent or degree of risk and uncertainty. When will it occur? Where will it happen? Who will be adversely affected? Serious hazards with a high degree of certainty are assessed more rapidly than less serious hazards with greater uncertainty. When the event is serious and the certainty is high, hazard assessment can be almost instantaneous with detection (e.g., seeing a fire in a crowded theatre), or it can take longer when either seriousness or certainty are unclear. When either the degree of hazard or the certainty are unclear, more people, or people with special skills and equipment, or more information are required (e.g., the accident at Three Mile Island). Initial assessments cycle through hazard detection, communication, and behaviour selection as more people become involved in the assessment of the hazard. As each new person or organisation becomes aware of the potential for harm, the situation is at least implicitly reassessed; in many cases, it is explicitly re-evaluated. Some assessments involve technological components, including specialised equipment, resources and personnel with skill to interpret, while others are non-technological in nature assessed through relatively simple rational choices with existing information.

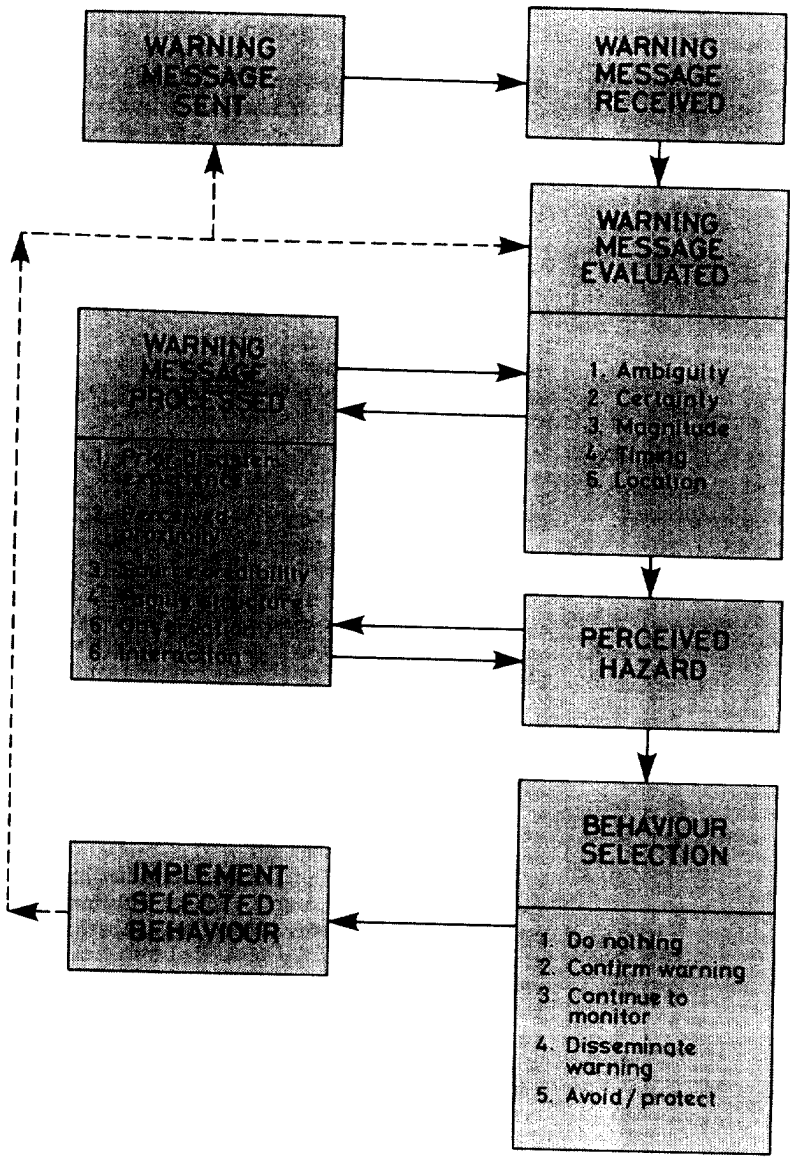
Becoming aware of the potential for harm and having assessed the extent of hazard, the next phase in the warning process involves the communication of warning. Communication or dissemination of the warning expands the number of people involved. Communication can be used explicitly to expand resources for assessment and response, and to disseminate information to people who may be affected. Implicitly, communication with others regarding potentially hazardous situations is a natural response to non-routine events. Communication provides a reinforcement from the social structure to confirm that the hazard is real and the proposed actions are an appropriate response. Communication among people that may be affected allows response organisations to co-ordinate their efforts and also allows others to confirm the nature of the threat and its assessment. Communication always involves people, as interpreters, and can involve technology as channels of communication.

Once the hazard is assessed and communicated, the issue becomes what the recipient of the message should do about it. For example, a fire department notified that a fire is in progress must decide what kind and how many resources to dedicate to the response. The selection of response behaviour may be characterised in several stages: immediate response options may be altered as additional information becomes available, protective action decisions may involve officials deciding what actions should be taken by and on behalf of those people likely to be affected selecting a response from among alternatives, and implementation may include the potential for further dissemination. Response can involve varying degrees of technology – escape on foot requiring no technology, evacuation via vehicle, or sophisticated technological protection.

The communication of warning ends with the recognition that the potential for harm is no longer present (negative hazard detection). When it is determined that the danger has been reduced or no longer exists, this information is communicated to peers, officials, and the public; recovery behaviour and the return to normality are activated.

The cyclical warning process is pregnant with opportunity for communication breakdowns, yet effective disaster response is contingent upon effective emergency warning. A relatively simple communication situation of two people speaking a common language in an austere room, and discussing a concrete subject is personal, immediate, relatively free of distraction, and has a high degree of certainty. In contrast, the communication of emergency warnings involves multiple inputs and outputs, involves communication with remote locations, over channels that are not completely reliable, sometimes concerning rapidly changing events, with high degrees of uncertainty, and involves delays in transmission. The cyclical warning process involves communication both among individuals and among and within organisations (e.g., governments at various levels, private, and officials of these various entities and the general public). To further complicate matters, the detection and assessment of hazard often involves highly technical information that is changing dynamically and with varying degrees of uncertainty.

While the specific actions taken in response to warnings are different (depending on the nature and stage of the emergency), both the general public and people involved in the emergency warning system respond through a similar process (Fig. 2). Beginning with the decision to send the warning, people should (a) receive the warning message, (b) evaluate its meaning, (c) process the message in terms of its application to them, (d) perceive the threat, (e) select appropriate behaviours, and (f) act. Because one appropriate behaviour issues the warning signal to people who have not yet received the message, the process begins a warning cycle for the (new) recipient.



2 Summary of warning process.

Sending the Warning

Sending the warning involves alerting people to the potential for harm and notifying them regarding appropriate protective action. An alert calls attention to dangerous and potentially dangerous situations without necessarily describing appropriate actions for dealing with the hazard. Notification provides information about the situation and how people can best protect themselves or avoid the potential insult. The objective of warning is to produce adaptive response(s) to the impending emergency. It must both alert the public to the potential for harm and notify them concerning the nature and range of appropriate response. Psychologically, detection of hazard creates a discomfort that is associated with the uncertainty of the event. Similarly, warning messages create discomfort associated with the information in the message concerning the event. In both cases, the information is evaluated in terms of its ambiguity, certainty, anticipated severity, timing, and location of impact.

Once a hazard has been detected, sending the warning involves a channel of communication and a source of emergency information. Communication along expected channels is more effective than communication along unanticipated channels, because of the likelihood that the channel will be monitored by a receiver. People generally expect to be warned via the electronic media[27] which have played an important role in the dissemination of warning in many disasters.[2,5,28,29,33,35,56] Quarantelli, Baisden, and Bourdess[36, pp 78-80] conclude that radio is the most widely used, effective and efficient channel of warning, because it is "... widely accessible, not very vulnerable to environmental impact, highly flexible and immediate, and generally given high credibility by the public."

The advantages of mass media channels of warning include their nearly universal availability, their ability to reach most people likely to be at risk, and the type of "broadcast" structure of the warning dissemination process they engender.[40] Even so, public officials cannot be expected to contact everyone; some people may not be tuned in to radio and television broadcasts.[14,49] Interpersonal communication of warning is critical for certain segments of the population (e.g., children, the infirm, the elderly or others who may fail to understand the meaning of warning signals and messages) as well as for those not attuned to centralised broadcast of emergency warnings.

Quarantelli and Dynes[37] suggest a middle range proposition that media channels of warning are relatively secondary compared to interpersonal dissemination of warning. Interpersonal channels contribute to the dissemination of warning, through a contagion effect,[18,40,43,44] which is the result of a de-centralised "birth" process.[19] Interpersonal channels of warning are usually salient and meaningful to the recipient,[3,4] because receiving warning messages communicate with others in their personal network of social contacts (e.g., friends, neighbours, acquaintances,

and family members). Social contacts also help establish the meaning of the warning in terms of decisions about appropriate responses. While personal networks are slower than broadcast mechanisms of warning, they are more focused on those people most likely to be threatened. At Three Mile Island, the proportion of people learning about the potential for harm via social networks increased as time passed. In addition, residents in closer proximity were more likely to find out about the accident from people they knew.[2] Paredes[29,pp48] also reports that people rely on social networks for initial warning and updated information in hurricane threatened areas. Hence, interpersonal sources disseminate warning to those who have not yet received the warning message, and "pre-process" that message in the sense of directing it to people who are perceived to need it most.

Repeating warnings from a variety of sources reinforces the message, thereby confirming the nature of the emergency warning, when the multiple messages are consistent.[39] When the warning messages are incongruent, inconsistent, or ambiguous, the associated uncertainty results in activities to reduce uncertainty either through response in terms of immediate ameliorative action (e.g., calling officials, looking for environmental clues), or by (continued) monitoring of the emergency's progression[38] (e.g., listening to the radio, staying awake at night to hear sirens). During TMI because information from a variety of sources was often ambiguous or inconsistent, ". . . many people were probably induced to evacuate".[22 p.1]

Inconsistent messages can also complicate the interpretation of the warning by impeding people's ability to establish its meaning.[21,31,34]

Sorensen, Rogers, and Clevenger[44] find that three sources of warning are crucially important in achieving effective warning. *Situation credibility* is most frequently established by people at the scene. Situation credibility establishes an element of understanding about the current situation based on direct involvement in the emergency. A *credible authority* is established by local officials who are either political or managerial. Credible authorities establish a degree of responsibility for emergency response by establishing who is in charge. *Technical credibility* is established when technical experts (e.g., scientists and engineers) are referenced in the warning message. Technical credibility enhances the believability of the emergency. Warning messages containing all three sources of warning are more likely to be effective. Data from a 1982 "piggyback" survey conducted by Gallup indicates that presidential authority is needed to establish situational credibility in national security emergencies, and local emergency managers establish feasibility of appropriate response.[10,42]

Many threats require the authority of the federal government. For some, only the federal government can provide warning (e.g., the monitoring of international, or military threats). For others, the resources required to provide adequate information are beyond those available to most state or local authorities (e.g., the provision of expensive advanced technology detection equipment such as weather satellites and Doppler radar). Often extensive research is required to determine not only what situations are hazardous but how they can be detected. Not only are the resources required to develop, instal, and operate such detection systems prohibitive, but independent systems are not required for the adequate protection of specific localities. Having been informed of the likelihood and nature of the threat local officials are (inherently) responsible for notifying the public concerning the specific actions needed.

Receiving the Warning

The inherent goal of any warning system is to produce adaptive behaviour in response to the impending emergency. Warning system effectiveness inherently depends on the receipt and credibility of the warning message. Receipt of the warning implies that the message is perceived as salient, relevant or important to specific people. For example, the President should alert the public to the potential for hazard in national emergencies, while local emergency officials notify people concerning appropriate actions. This process takes advantage of the authority of the President, which augments the salience associated with the local official. Receipt and credibility of warning are comprised of more than the "message sent," and it includes both "hearing" and "understanding" the relevance of the warning message – the interpretation of the warning message and its salience.

While there have been exceptions (e.g., the Big Thompson flood reported by Gruntfest[13]), receipt of warning is related to the age of the potential victims. The diverse and fragmentary evidence which exists suggest that on the whole older people are less likely to receive warning than young people, irrespective of whether the source is formal or informal. This may be a function of the isolated living arrangements or from the relatively high proportion of older people afflicted with disabilities that interfere with reception.[7] Based on the analysis of attitude data regarding the willingness to acquire (or even accept even free), in-home warning devices, Rogers[42] posits that older people view themselves as less able to take adaptive action and find such action least effective for themselves. In an emergency, people tend to rely on what is familiar, and this tendency may be particularly strong among the elderly.

A substantial number of people cannot discriminate between the alert and notification aspects of warning.[11] "Warning messages are complex phenomena. [The message] . . . should be as specific as possible and include information about both the threat and . . ." protective actions.[3, pp.200-201] Warning messages are subject to a wide variety of interpretations, in terms of salience and implications for specific adaptive responses. The potential range of meanings associated with the warning message are narrowed when the message is specific concerning the impending threat and appropriate actions. People must not receive the warning message only physically, but they must understand its meaning, recognise its salience, and interpret the message as relevant for them – whether real or not, as if it were real. In the Colorado floods in June 1965, some people did not believe the evacuation warnings. "Because of this, attempts to remove residents from endangered areas prior to the flood were only moderately successful."[55, p.36] A few residents were allowed to remain until the flood waters flowed through their homes, when they were more willing to leave.

People are more likely to believe warnings from official sources. Warnings delivered in a personal manner are usually more effective than those communicated by an impersonal channel. Sometimes, however, even personal warnings are ineffective. In the Big Thompson flood, state patrolmen individually warned residents to move to high ground, but their pleas were occasionally unheeded; in the Rapid City flood, the personal pleas of the mayor at the riverside were ignored by many. These behaviours were probably related to the absence of physical signs of the hazard downstream from the source of the threat. People seeing other people around them responding to warnings are more likely to respond. A group of peers is less likely to respond to the hazard warning than is a family.

Apparently, there can be peer pressure to underestimate the hazard or scoff at the danger. People are more likely to believe the warning and respond if the danger is perceived to be real. In very unusual events (e.g., the Big Thompson flood), these perceptions can cause problems. In more common events (e.g., Mississippi flooding, tornados in the Midwest, moderate earthquakes in California) previous events help clarify the impending hazard. As subsequent warning messages give more precise times and location, more information about actions to take, clarify earlier ambiguities, and become consistent with other sources of information, the more likely people are to believe them and respond.

Consistent, unambiguous, official and authoritative warning notifications that are delivered in a personal manner and that contain specific credible information maximise the potential for ameliorative response to the impending hazard.[25] In the Colorado floods of 1965, Worth and McLuckie[55,pp.70-71] found that people, "... interpreted warning from peers and mass media as urging evacuation of specific areas and providing descriptive information ..." Warning from authorities were perceived as bona fide evacuation notices by nearly 70% of the people. In 60% of the cases, people were sceptical of peer and mass media warnings, while those from authorities were viewed with scepticism in only 22% of the families. The receipt of warning from official sources tends to reduce uncertainty and to enhance adaptive response.

Belief that hazard occurrence is imminent and is likely to impact one's own area is critical in the adoption of adaptive crisis behaviour. Message content *per se* influences belief. The more accurate and consistent that the content is from message-to-message, the greater the belief.[25,p.21] Second, "belief in eventual impact increases as the number of warnings received increases." Believing the warning message is not sufficient to assure adaptive response, that may be in response to misunderstandings associated with the warning message. "Belief in real situational danger and advisories from officials were cited most frequently as the critical reasons for evacuating in both the nuclear and non-nuclear incidents".[30,p.xi] The salience of the warning message and recognition that the danger is real are primarily a function of the credibility of warning and its translation into adaptive response.[25,p.21] The estimation of the likelihood of occurrence, spatial and temporal imminence, and potential consequences of not taking ameliorative action define the salience of the warning message.

The notification aspects of warning should place emphasis on relatively simple protection or avoidance measures that can be implemented through relatively simple acts and are recognised as consisting of familiar practices. This kind of communication encourages people to take effective action while demonstrating how common "everyday" actions (e.g., get in a vehicle and drive to city A) can provide an adequate measure of protection or avoidance.

Notification at the household level enhances the credibility of emergency information by providing salient information to a narrowly focused population that is likely to be impacted by the impending hazard. In-home warning devices vastly improve capabilities to direct warning messages to specific communities and neighbourhoods, likely to be impacted, making received warnings spatially and temporally more salient. This enhanced salience increases the credibility associated with the warning message; hence, the warning message, including suggestions for ameliorative action, is more likely to lead to adaptive action.

Evaluating and Processing the Warning Message

Recipients evaluate warning messages on the basis of clarity, relevance and believability, which includes resolving ambiguity and uncertainty, and assessing the magnitude or severity, timing and location. Processing the warning message involves social processes (personal experiences, the social structural aspects of the situation, and individual propensities) used to evaluate the warning message to balance the information contained in the warning message with extant information observed in the environment. Effective warning messages require a delicate balance between fear-arousing and fear-reducing statements.[16] A vivid mental image of the impending crisis is evoked by describing the impending danger in detail. The fear-arousing statements in the warning message reduce the potential for surprise, while invoking response. The realistic presentation of mitigating factors provide information regarding the action of authorities and those of affected individuals. This fear-reducing component of the warning provides the foundation for adaptive response. The fear-arousing aspects of the warning alert the population-at-risk to the potential for harm. The fear-reducing statements are comprised of notification concerning appropriate mitigative actions.[40] The lack of initial response to ashfall warnings associated with Mt. St. Helens has been attributed to a nonspecific warning message regarding (1) the area of impact, (2) precautionary actions, and (3) a sense of urgency.[51] In this case, the warning system failed to provide "fear-arousing" urgency or the "fear-reducing" prescriptions for action.

Experience with previous disasters provides data used in evaluating of the warning message. Rogers[38] argues that the perception of hazard and hazard experience are inherently related, because *ordinary knowledge* is comprised of experience, and the hazard perception rests firmly on that knowledge. Cognitively people perceive hazard by using heuristics, which simplify the process.[17,45-89] Prior to an actual exposure, this inventory of experience is used to estimate the likelihood of the hazard being actualised. While expected hazards are rarely correlated, survey data seem to indicate that people generally know the kinds of hazards they face.[38]

People evaluate warning messages in the context of the kinds of hazards that they believe are possible in their area. Prior experience is a special indicator of this (at the individual level) likelihood of hazard occurrence. Earthquake warnings issued for the Great Plains States initially have a low level of credibility, because earthquake prediction remains scientifically ambiguous and uncertain, and recent experience with earthquakes is limited, even though the area historically has experienced major earthquakes prior to becoming heavily populated. This initial credibility gap can be overcome. At least for common hazards, (i.e., where there is some experience even if not in the particular area) clear explanations for the "new" threat to the area will have to be specifically identified.

If an individual has already become aware of the potential for a crisis, the warning signal itself can serve as confirmation of the crisis expectant observations. Rogers and Nehnevajsa[39] conclude that it is imperative to recognise that the official warning signal confirms the onslaught of hazard, that were identified in the crisis expectant period. Through the identification of environmental clues, or other preliminary signals of an event, individuals may be "expecting" a crisis to emerge. The official warning serves to confirm the impending hazard, when crises are expected. In a more abstract sense, the evaluation of the warning message is placed directly in the context of past experience and the immediate sense of danger.[52]

One of the potential problems associated with individual reliance on past experience with disasters as a guide to the appropriate actions to be taken under the present conditions is the variation of conditions from crisis to crisis. This rather general topic is highlighted by several prominent cases, including false-alarms, near-misses, and remote-misses. Scientific and technical skill cannot define accurately enough the time, magnitude, and zone of impact for many hazards and, hence, warn only in situations where the threat becomes actualised. In summarising the situation following the 1978 flash floods in Texas, the US Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service (NWS)[49, pp.7-11] points out that:

> Life-saving actions by public officials and others were generally not taken until the flood waters actually became a real threat. Why? Scientific and technical skill is not available to define accurately the magnitude, time of occurrence, and geographic location of each flash flood. We over-warn. During a typical year, NWS offices issue many flash flood watches and warning, but few really serious flash floods occur. Further, relatively large areas are typically watched/warned for an extremely localised event. This tends to desensitise individual citizens and public officials to the danger. This situation is a direct result of our technical limitations. Many weather systems have the capability of producing serious flash flooding – but only a few do occur. We do not have the observing and forecasting tools to discriminate adequately between the two.

On the other hand, the public can become particularly aware of alarms in the wake of particular situations or near-misses.[16,p.87] The Texas City disaster[23] sensitised people

> . . . to fire alarms, after a series of devastating explosions demonstrated that earlier warning signs should have been heeded. Similar changes in readiness to respond to warning signals have also been observed as a consequence of direct experience with other danger stimuli. Formerly unnoticed storm clouds and the sounds of rising wind come to evoke strong fear reactions in the survivors of tornado disasters, producing sleeplessness, obsessional watchfulness, and other post-traumatic reactions that can be properly described as hypervigilant in character.[9,26] Such traumatising events have been described as "near-miss" experiences, in contrast to "remote-miss" experiences in which warning signs occur without being accompanied by any distressing danger impact.[24]

Nonspecific emergency warnings, aimed at rather broad geographic areas, tend to induce minimum adaptive response to impending crisis. For example, Brouillette[1] reports that response to tornado warnings among people frequently exposed to nonspecific tornado warnings encompassing large geographical areas minimised the perception of the apparent danger. Generally, these alerts are adequate, but specifically they are nonexistent. In the Palm Sunday tornados in Indiana (April 11, 1965), warnings were announced over radio and television in the context of six to twelve state-wide tornado warnings a year. While the warnings were issued on the day of the tornado impact, many people may not have received them and ". . . others may have taken them with a grain of salt since similar warning have been issued in the past . . ." and the hazard failed to materialise. Brouillette[1,pp.35-36] points out that sometimes emergency officials issue a warning expecting people to respond automatically, which fails to consider the effect of past experience on the interpretation of the alert.[8]

The relationship between warning and adaptive crisis response is not a simple stimulus-response relationship. It must account for the many human elements that effect the sophisticated ways in which people process warning information.

Because abstract hazard warnings tend to minimise adaptive response and often lead to maladaptive action, emergency warnings need to be as specific as possible. Alerting should include the nature of the threat, and the area and likelihood of impact. Notification should further specify the nature of effective protective and avoidance measures available to the public by emphasising simple actions (often taken jointly with others) of amelioration.

Conversely, past individual experiences with actual hazards can enhance adaptive response. Gruntfest[13, p.231] provides three examples of family responses in the Big Thompson flood.

> One family which survived the Rapid City flood of 1972 immediately heeded the first warning they heard while camping at the lower end of the canyon. A second family noticed the river rising and, recalling their knowledge of the flooding potential of the bayous in Texas, headed for higher ground. A [third] family familiar with tornadoes received a warning and followed the instructions of the sheriff's deputy without hesitation.

Even though these examples illustrate the point, one of the most consistent findings of the disaster literature concerning warning, summarised by Leik *et al*,[20, p.42] is that ". . . the primary effects of standard warning messages are to get people to seek additional information. They do not motivate people to consider evacuation or to evacuate." This illustrates the point that people do not respond (automatically) to emergency warning alone or in a vacuum. They respond in the context of a personal life history, with all its associated values and meanings. People respond to emergency warnings first by adapting more familiar behaviour to the (sometimes rapidly) changing environment.

Because people respond to warnings by adapting familiar behaviour, emergency preparedness and associated drills create an environment where the somewhat unique responses required of emergency situations become a part of the more routine behaviour associated with relatively normal periods.

An "all-clear" signal is needed to assist people in determining when the hazard is reduced. Because not all warnings are followed by actualisation of the hazard, people cannot be sure when the immediate danger is over. Because the perception of hazard during the onslaught is not uniform, "all-clear" signals let people at risk know when the hazard has passed and they can return to normal activities or begin search, rescue, and recovery. They also let people return to normal when the hazard fails to occur. Deaths have been attributed to returning to impacted areas prior to impact.

Confirming the Warning

Even after the warning message is issued, the search for information continues. The confirmation of warning involves the search for additional information about the potential hazard. It is an attempt on the part of the warning recipient to clarify the warning signal. Having received the hazard warning" . . . most people will make some attempt to check on the information",[20] which is a hazard assessment. When tornado warnings were received about two-thirds of the people reported seeking additional information.[20]

Public perception of hazard, receipt of warning, and confirmation affect the response to pending emergencies. Warning information and confirmation are important because they are the basis of hazard assessments. The environment alone also serves as a source of confirmation.[4,20,54] In many disasters, people look to the environment to confirm the warning information – observation and confirmation. In floods, people attempt to observe the river. In nearly all disasters, another form of confirmation involves people evaluating their own actions in the context of the behaviours of others.

> Among the important psychological variables in the operation of a warning system involving human operators is the frequency with which the person receiving a danger message seeks confirmation before relaying it. This subjective need for feedback in a system may affect not only the relaying of the message from a given point to the intended audience, but also the system as a whole, through the overloading or bypassing of key points. It is most difficult for human beings to operate "automatically" in a warning system.[54, p.91]

Warning systems must be activated early by issuing the warning to account for potential delays. The alerting message should be followed by additional information that includes recommended protective actions. While time may not always permit, people should not be discouraged from confirming the warning message with friends, neighbours, and relatives. Such actions verify the warning messaged for both parties, as well as disseminate the warning.[18,40,41]

The confirmation process involves searching for supporting information. People are likely to hear and pinpoint various parts of the message, requiring dissimilar amounts and types of confirmation. To some extent, confirmation may contradict the original source of warning. But even so, confirmation is a natural hazard assessment in the cyclical process.[5,p.343] Repeated warnings provide a self-confirming message of potential danger. If the warning message includes notification regarding appropriate responses, repetition also strengthens adaptive response.

Confirmation of warning is affected by where people are located and whom they are with. Families that are together when warned are less likely to confirm the threat than are families that are separated. When together, family members are "built-in" sources of confirmation. When people are close to the potential disaster area there are more sources of information for confirmation, and they are more likely to hear the confirming warning in the social network.

People who are more likely to require protective action are more likely to be warned by various sources. They are also most likely to seek, receive, and confirm the warning message. People tend to share the induced stress of the impending emergency situation with members of their social network. This sharing tends to confirm the warning and to reassure friends, neighbours, and relatives. Because humans are social beings, during times of impending crises they are likely to join forces to enhance their fundamental desire for life, health, and protection against outside threats.

This tendency can often lead to a convergence of calls for additional information which can make it impossible for response organisations to communicate.[1] Telephone system overloading has prompted public officials to request that people refrain from using the telephone in disasters in some cases. By urging the public not to use telephones, public officials also limit an important channel of warning information. The evidence indicates that urging people not to use some channels of communication (e.g., telephone) is useless. People will use telephones because it is a normal routine behaviour, easily adapted to crisis conditions.

Seeking additional information is a natural outgrowth of the way people process information. To quench the public's desire for information in crises without overloading telephone lines, people should be encouraged to confirm the warning message via other modes of communication.

Through the identification of environmental clues or other preliminary signals of an event, people may be "expecting" a crisis to actualise. In such cases, the official warning confirms the reality of the impending hazard. Neither warning alone, nor clues of an impending hazard alone, are likely to generate sufficiently adaptive activity without reinforcement.

While the receipt confirmation, and credibility of the warning message can lead to action, there is no way of knowing whether the nascent activity, in light of the impending danger, will be adaptive or maladaptive.

> Despite the excellent warning lead-time and multiple sounding of the sirens, some people of Wichita Falls either did not hear the warnings or failed to take prescribed lifesaving actions. More than 40 died, and about 1,700 were injured. As the storm bore down, those who sought the safest refuge in their immediate surroundings generally fared well. Those who were caught in automobiles and trucks made up a high percentage of the fatalities. People from the shopping centre took shelter in refrigerator vaults, in restrooms, and under counters. A number of families used bathtubs, hallways, and closets. Several got extra protection by covering themselves with mattresses and pillows. They survived![50, pp.2-3]

Warning information should be reinforced during the warning itself. Whenever possible it may prove useful to follow warning messages with a brief list of some of the easily recognised clues of impending danger.

Some subcultures obtain less confirmation before responding to warning signals. While very few studies have examined non-English speaking subcultures, research suggests that there are some significantly different responses, compared to others in the area. Such subcultures tend to obtain less confirmation of warning from public authorities, while seeking shelter with relatives regardless of social class. It is not yet clear whether the confirmation processes are different among subcultures. One explanation suggests that it is a function of the language barrier. Another suggests it is a function of cultural differences. It could also be a result of their marginal position in the social structure. In any event, warnings need to be communicated in a language that is understandable by the recipient. Warnings should use simple, everyday language, consisting of unqualified declarative sentences. In some localities, multilingual capabilities may be required for alert and notification processes so that confirmation opportunities for non-English speaking people are not lost.

There are four types of warning confirmation.[55] Observational confirmation involves collecting interaction from the environment (e.g., watching the river rise or seeing the storm front develop). People are more likely to believe the warning when changes observed in the physical environment are consistent with its message.[25] Some people attempt to confirm the warning message with authorities but people will tune into radio and television for confirmation. Even though peers may have less information or even contradicting information, appealing to peers is an important confirmation mechanism. The confirmation process involves warning dissemination, hazard detection, assessment, and decision making; it is also the first step in determining appropriate behaviour and response. Latent confirmation occurs when people unintentionally confirm the warning message (e.g., receiving invitations from friends and relatives for shelter).

Perceived Hazard and Behaviour Selection

The ways in which people respond to warning are affected primarily by the stimulation provided in the warning signal. However, people listening to the same warning message, can exhibit considerable variation in terms of what parts of the message they receive, focus on, and believe. Furthermore, "... people are stimulated differently depending on who they are, who they are with, and who and what they see."[53,p.188] Because adaptive behaviour is different for hazards of various kinds and even for different occurrences of the same hazard, people are characterised by distribution of responses. When forewarning is extended (e.g., hurricanes), the original stimulus alerts the area that action may be required in the future. One adaptive response involves continuously monitoring the situation as it evolves.

Despite a majority of people who engage in monitoring prior to the impact in hurricanes, distinct gaps in the monitoring process often leave people vulnerable to impact. While the early evening monitoring was significant, the cessation of the monitoring by over half of the respondents does not mean that other arrangements were or were not made.[29] The data do not appear to answer the questions regarding the shifting of monitors, or the informal systems among neighbours to monitor for the neighbourhood and the like. Monitoring in emergencies with long onset periods probably involves less intent to monitor than simple information sharing.

Warning messages that are inappropriate (e.g., given the individual's geographic area), are unlikely to lead to nascent activity. When the warning message is received, confirmed and credible; nascent activity is likely to ensue.[39,p.166] "Adaptive behaviour in response to an emergency is not a natural outgrowth of the situation, even in the surge period where the authenticated hazard has been confirmed via official warning. The surge period is, by definition, a period of limited time."

The words "Because the time-frame is limited . . . , panic" have often been ascribed to this phase, although true panic behaviour seldom occurs. However, much noneffective behaviour does occur when there is an absence of a prepared plan or little provision for leadership to improvise an adequate response.[12,pp.65-60]

Perry, Lindell, and Greene[32,p.ix] summarised the human elements of the emergency warning system in terms of the implication for federal crisis relocation planning programmes. The implications they observe for evacuation generally apply to adaptive behaviour. Perry *et al.* argue that adaptive response to the crisis relocation requests associated with nuclear attack:

a . . . would probably be higher than the response usually observed under natural disaster conditions.

b . . . Lack of prior experience with nuclear hazards would probably generate a high degree of "reflexive fear",[15] making compliance with protective measures more likely;

c the source of the warning – the President of the United States – would be considered authoritative and credible by most citizens;

d assuming news media would describe events leading up to the time of the request to relocate (a crisis-expectant environment), the public would have an opportunity to develop a perception of real threat prior to the warning to leave;

e since the actual destructive potential of attack is objectively great, and because the potential has been exaggerated in the popular literature, citizens would tend to define personal risk as exceptionally high.

The potential degradation of adaptive response under conditions reflecting false alarms, near- or remote-misses, and the accuracy of spatial and temporal dimensions of warning messages are critically important in the selection of appropriate emergency behaviour. Public response to warnings is based not on the actual hazard potential but rather on their perception of that hazard and how that perception stimulates them to behave. Emergency officials must be prepared to influence the public's perception of hazard, particularly in overcoming obstacles to the selection of adaptive behaviour in response to emergency warnings.

Implications and Conclusions

Emergency warning systems are comprised of technological and human components, which repeatedly interact in the warning process. Technology generally establishes the channels of communication, providing the tools or mechanisms of communication. People interpret the meaning of the warning message, providing analysis, making decisions and using judgment. Because people and technology both form integral links in the warning process, they are indispensable parts of an effective warning system.

Warning systems repeatedly cycle through processes involving hazard detection, assessment, communication, and behaviour selection with each person or at least some minimal social unit like the family – reiterating the process as they become aware of the potential for harm. As the number of people involved in a given warning situation increases the number of warning cycles also increases. As in the classic communication experiments, the fewer people involved in the communication of emergency warning the more effective the process. This occurs not only because of the decreased message distortion associated with passing a message through a shorter communication chain, but also because of the reduced number of cycles involved. Fewer assessments, discussions and decisions are made during those cycles. In addition, because the process involves decision-making, increasing the number of people involved also makes consensus more difficult and can increase uncertainty for some people. A few people analysing the situation, exercising human judgment, and making recommendations about appropriate response(s) are more effective than many.

At a maximum, every person involved in a situation completes the warning cycle, but some people simply are not equipped to detect and assess the hazard, to communicate its meaning with others and to select appropriate response(s). For many these functions are performed on their behalf by others. Children are seldom expected to perform these emergency warning functions, rather parents and guardians complete the warning cycle on behalf of the family. Fire departments seldom allow all fire fighters to perform all these functions; it simply is not effective to have all people in a response organisation completing the warning cycle. Thus the organisation, through its management structure, completes the warning cycle and responds as a unit. However, for people to allow others to assess the hazard, communicate it to others and select appropriate behaviour on their behalf, a degree of confidence is implied in the social unit's abilities to make these judgments. For families, confidence probably rests in an implicit trust that governs family decision-making, but for organisations such confidence develops on the basis of experience, association, and perceived competence. By fostering association among organisations, even small social units can respond more effectively by becoming familiar enough with others that less time is needed to reassess, discuss, select a response and respond to the impending event, while maintaining their independence and freedom. In addition, larger

organisations benefit from this kind of association by building greater confidence in the collective judgment. This reduces the amount of reassessment, discussion, and decision-making time, and thereby develops a more effective warning system.

Because emergency situations are dynamic, the hazard detection function continuously discovers new or changed aspects of the problem. As new information becomes available, it is evaluated, communicated, and acted upon via the emergency warning system. As the complexity of the emergency increases, so does the potential for cycles of the warning system. Hence, in all disasters, particularly in rapidly changing situations, people will use judgment to decide when additional information is significant enough to reassess, communicate, and select alternative actions. Emergency warnings that limit the number of information changes communicated will be more effective than warnings that do not. However to maintain confidence and credibility, authorities must communicate significant developments in the situation. Hence, emergency managers will have to find the balance between reporting significant developments and overwhelming the communication system and the recipients with information.

As each person or social unit is warned they become aware of the hazard, they have to assess the hazard to establish its meaning, communicate with others and select appropriate behaviour. Warning systems either have to allow people time to complete the warning cycle or they have to provide sufficient information to minimise each phase of the cycle. To the extent possible, warning messages should contain information to facilitate assessment by the recipient, reduce discussion time, and provide answers regarding appropriate protective actions.

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