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# Local Preparedness for Chemical Accidents: A Survey of U.S. Communities

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## Abstract

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The preliminary results of a survey designed to assess the state of emergency preparedness in communities across the United States aid in the development of a conceptual approach to emergency management. The approach identifies the relationships among existing emergency-management systems and practices and assesses their effectiveness in alerting and notifying the public. A comparison of data gleaned from a survey of emergency-preparedness officials permits comparison of existing public-alert and notification systems with state-of-the-art technology, procedures, and management systems. The study also addresses the potential problems and constraints likely to thwart timely effective warning in the advent of an emergency. Finally, the authors make recommendations for improving public-alert and notification systems in chemical emergencies.

## Introduction

This paper describes preliminary results from a survey designed to examine community preparedness for fixed-site chemical accidents. The survey was conducted as part of a larger study in support of TITLE III of the 1986 Superfund Amendments and Reauthorization Act (SARA). Section 305-b of TITLE III requires the U.S. Environmental Protection Agency (EPA) to prepare a report to Congress reviewing current emergency systems for chemical acci-

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dents (USEPA, 1987). In support of that report, our research sought to identify the technology, procedures, and management practices used to alert and notify the public in conjunction with a chemical release. This study develops a conceptual approach to identify the relationships between emergency system characteristics, management practices, and system effectiveness with respect to alert and notification of the public.

Data from a survey of community emergency-preparedness officials are then utilized to compare existing public alert and notification systems to the state-of-the-art technology, procedures, and management practices. Second, the research assesses problems and constraints that would interfere with a timely and effective emergency warning. Finally, the research assesses where significant improvements can be made in public alert and notification systems for chemical emergencies.

## The warning process

Several general models describe the warning decision process of individuals (Janis and Mann, 1977; Leik, Carter and Clark, 1981; McLuckie, 1970; Mileti, 1975; Mileti and Sorensen, 1987; Perry, 1979; Perry and Mushkatel, 1984; Rogers and Nehnevajsa, 1987; Williams, 1964; Withey, 1962) and organizations (Anderson, 1969; Mileti, 1975; Mileti, Sorensen and Bogard, 1985; Sorensen and Gersmehl, 1980; Sorensen and Mileti, in press; Worth and McLuckie, 1977). The organizational model defines the general components, common decision points, and linkages that are somewhat characteristic of all warning and protective action decisions. Figure 1 illustrates the key decision points and communication linkages that define the process.

The model has three basic components: a detection subsystem, an emergency-management subsystem, and a public-response subsystem. The initial stage in the decision-making process is the detection of hazard or the recognition that the environment poses a hazard. Once the hazard is detected, the second key decision is whether or not the hazard poses a threat. Once the threat is judged to be significant, the detector/assessor must decide whether or not to alert the public or officials to the risk and potential damages and, then, who should be notified of the threat. A notification of a public official typically results in the activation of an emergency-response system. The organization initially notified must decide who else to involve in a decision to warn. Once mobilized, emergency managers must decide whether the risks warrant warning or protective action. Finally, a decision is made as to what type of protective action is needed and whether to and/or how to warn the public.

The organizational component of an emergency can range from a simple situation involving a citizen-generated detection and alert mechanism to a complex situation involving a large scientific monitoring program accompanied by a decision-making structure in a bureaucratic government. The process is often





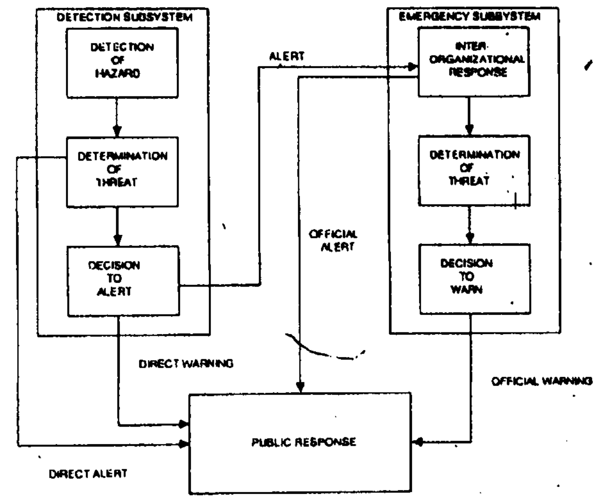


Figure 1. A model of a warning decision system. (From Sorensen and Mileti, in press).

interactive with numerous dynamic communication flows regardless of the scale and complexity. As such, the model implicitly recognizes the need for integration between the subcomponents, the need for timely and effective communication linkages, and the importance of decision making, including that associated with public response.

The remainder of the paper discusses the various components and linkages in the model using data from a survey of communities with a fixed-site facility that stores, uses, or produces hazardous chemicals. The next section describes the methodology used to collect that data.

## Methodology

### *Unit of analysis*

The unit of analysis for the study is the 'community'. A community is a social unit, not necessarily matching with a local political jurisdiction. Since the topic of interest is in the community's response to a chemical emergency, specifically to alert and notify the public, the community is represented by the local political jurisdiction responsible for emergency alert and notification and planning for chemical accidents.

If facilities are located in a sizeable city, this will likely be a municipal government or a combined city/county government. If the facility is located outside a major city, in a rural area, or an unincorporated town, this will likely be the county government. Facilities in small towns could be served by either a county or city government with respect to the warning responsibility.

Thus the mapping of the facility into the appropriate local jurisdiction is somewhat problematic because no written data are maintained on what local organizational level is responsible for alert and notification of the public on a systematic and comprehensive basis.

*Sampling approach*

The EPA selected facilities that store, use, or produce one or more of 20 hazardous chemicals to represent current industry emergency-planning, mitigation, prevention, and monitoring practices. Communities were selected for study by matching a facility to the community with jurisdiction over that facility. The approach used to identify the appropriate community organization tapped the Federal Emergency Management Agency's (FEMA's) national data base on local emergency-response organizations. That data base, which contains information on more than 3300 local emergency-response organizations at the city, county, and combined city/county levels, represents the best available data on local emergency responsibilities. The concept matches facilities to organizations in this data base at the city and county level. The city was used first, because it is, in most cases, the smaller unit (i.e., a single county may contain multiple municipalities, each with its own emergency-response organizations). The match was then made at the county level. When no matches were found for a facility, telephone calls were made to ascertain jurisdictional responsibilities.

*Sampling frame*

EPA used a purposive sampling frame to select 525 chemical facilities for inclusion in the study. The sample of communities was selected from the jurisdictions represented as follows. First, the community in which each facility was located was matched to city-level emergency management agencies in FEMA's data base on community emergency-planning organizations. After all matches were made, counties in which the remaining facilities were located were matched to county-level emergency-planning organizations in that same data base. When more than one facility matched a community or county, a single facility was selected as the reference point. The criteria for choosing facilities among multiple facilities within a community, first, eliminated facilities known to be suspect based on the returns of facility questionnaires. Second, facilities





that matched identically on city name were selected. Third, facilities with the rarest chemical (out of the 14 chemicals with less than 100 facilities) were chosen. Fourth, facilities using, storing, or producing chlorine were selected. Fifth, private companies were chosen. And, finally, facilities were selected at random from among the pool of remaining facilities. At this stage, 248 facility-community matches had been made. One hundred sixty-eight facilities were eliminated because they were not chosen when selecting a facility for a given city. Seventy facilities were dropped because they were not chosen at the county level. Thirty-nine facilities did not match the data base at the city or county level. Of these, appropriate local emergency-management organizations were identified for 29 facilities. Ten facilities were never matched to a local planning organization. This resulted in a total sample size of 277 local emergency-planning organizations that match with a facility contained in the EPA sample of facilities.

Theoretically, some of the 70 facilities eliminated at the county level could be included if they were located in a municipality for which a local organization for alert/notification existed separate from the county. No attempt was made due to time limits to identify such possibilities.

The screening question on the second page of the questionnaire contained a response that the facility existed but was located in another jurisdiction. In total, eight community organizations returned the questionnaire with another jurisdiction listed as being responsible. In all cases, questionnaires were sent out to the replacement communities.

In several cases, the communities receiving questionnaires indicated that the facility listed for the community did not exist, but they had other facilities with hazardous chemicals and wanted to complete the questionnaire. In such cases, they were instructed to fill out the questionnaire and note on the instrument the name of the facility used as a reference point.

The questionnaires were mailed to the chief or head of the local agency responsible for emergency planning in each local jurisdiction defined to be in the community sample. The majority of these were identified in FEMA's Hazard Identification Capability Assessment and Multi-Year Development Plan for Local Governments data base. Instructions were included to have the recipient of the package give it to the appropriate person in the jurisdiction or area who was in charge of emergency planning for the facility. Follow-up letters went to all communities not initially returning the questionnaire. Four questionnaires were returned with inaccurate addresses and remailed at later dates.

*Response rates*

It was estimated that with telephone follow-up calls, 60 to 70% of the 277 communities receiving the questionnaire would respond. As of March 1, 1988, responses from 59% of the sample had been received with 49% of the total being completed questionnaires. The other 10% were returned with the completion of the screening question indicating that the facility did not (or no longer) exist(ed) in the community.

## How will facilities notify community officials?

The linkage between the chemical facility and the people in the community is usually not direct. Warning decisions usually are made by city or county officials. The initial step of a warning is for the facility to notify the appropriate community officials or point of contact within the community system.

Communities expect facilities to notify them in a number of different ways. The primary channel is by commercial telephone. Sixty-six percent of the communities cited telephone systems as the primary link. Approximately one-third of the communities stated that radios would also be used. This is not unexpected: telephones and radios represent the most common forms of communication in general as well as in emergencies.

But experts do not consider telephones and radios as highly reliable forms of communication. Telephone lines may fail (sometimes from the same event that caused the chemical accident) or be busy. Radios often operate at different frequencies, are found inoperable, or are difficult to use because of heavy traffic on the appropriate frequency.

Some communication systems are designed to overcome such problems. These include dedicated telephone lines (a separate line not linked with commercial traffic), 911 telephone systems, dedicated radios, pagers, and special alarm systems. None of these are commonly used in the communities studied, at least between the facilities and communities selected. Dedicated telephones were cited in 5%; dedicated radios were found in 4%, pagers in 2%, and alarm systems in 4%. Only 3% judged that they would use the 911 emergency system to receive an alert even though one or more of the communities have 911 systems in their EOC. In addition, some locations relied on less sophisticated or more passive means of alerting. These included using a messenger (3%) and relying on sirens or loudspeakers (7% each). Such forms of communication are not highly reliable.

It is noteworthy that more than one primary link existed between facilities and communities. On average, a community specified 1.5 primary channels to the facility. This means, however, at best, 50% of the cases rely on a single means of communication. Fewer communities mentioned the availability of backup channels: About 30% of the sample claimed to have some backup capabilities. Backup channels were varied; 15% cited two-way radio, and only 5% cited either a dedicated backup or pager.

Overall, the findings are clear. The communication link between facilities and communities is neither highly dependable nor reliable. The main linkages are ones which are frequently the cause of warning failures. Backup equipment





is not adequate in many cases. This is not to say failure is certain, merely that state-of-the-art communications equipment exists in relatively few situations.

## How reliable is the communication process?

The previous section examines the physical linkages between the facilities and the communities. This section addresses the communications process from a community perspective. First, we examine the aspect of interaction clarity, which refers to the understanding an organization has about the person in other organizations with whom they will communicate. Second, we examine whether there are vulnerable times of the day and week in the communications link. Third, we take up the degree to which procedures have been established to describe the communication process. Finally, the information needed by communities to make warning decisions is addressed.

### *Clarity of interactions*

Warning systems are more effective when it is known who will issue the alert and who will receive it (Drabek et al., 1981; Dynes, 1978). In this case, additional precision calls for defining who at the facility will alert officials and who in the community will receive that alert. Warning systems are also more effective if redundancy in this function is designed into the system. Thus, it is also important to know who will contact whom when or if the primary link breaks down.

First, consider knowledge among community officials (measured by the identification of the name and position of people responsible for sending and receiving emergency notifications) concerning the alert process of the reference facility. About 50% of the communities identified the name and position of the person at the facility responsible for the alert. Another 18% identified the position but not the name. Twenty-five percent of the sample identified neither name nor position. Ideally, every community would know at least the position of the person at the facility responsible for alerting them.

One would expect a poorer knowledge of backup communicators. Such is the case with 38% not knowing the name and/or position of the backup at the facility. Twenty-six percent could identify the person by name and position and another 28% by position only. This suggests only a moderate level of knowledge about interactions. This is a conservative stance as responders had the opportunity to retrieve the information from a plan or to call the facility and ask (as some did).

Even more important from the community's perspective is knowing who will receive the alert. Replication of the same inquiry revealed that 51% of the communities could identify the name and position of the person who would receive the alert. Another 39% knew the position that would receive the alert. Only

10% failed to identify the name, position, or both, with only 2% responding in the unknown category. As expected, knowledge of the backup decreased. Eighty-two percent identified the name or position of a backup. Those not identifying at least the name and position rose to 16%. Thus the clarity of interaction is much higher within communities than between communities and external organizations.

Finally, we can examine the ongoing communications process. Because emergencies are dynamic events, new information may affect the warning decision or change the content of warning messages. Hence, it is important that organizations maintain communications. The reliability of communications equipment and the use of established contact points between organizations will determine the effectiveness. Seventy-nine of the communities identified by name or position, or both, the person in the community responsible for ongoing communications with the facility. On the other side, 21% did not identify either the name or position of the communications contact in the community.

Overall, a high percentage of communities have established a point of communications within the community, which helps promote effective communications in an emergency. Fewer know who will contact them from the facility. The smaller percent who seem unsure of communications have a greater potential for not receiving an alert from the facility or miscommunicating information when contacted.

*Vulnerable times*

An emergency can occur at any time within a 24-hour period. Most larger urban areas maintain a continuous point of contact; other communities do not. To ascertain the extent to which communities could not be contacted, we asked the communities to specify times in which it would be difficult for the facility to alert them. The lack of a 24-hour contact could prevent or delay a timely public alert.

The vast majority of communities maintain a 24-hour communications capability. (This is not to infer that the communications will be made to the contact point.) Eighty-eight percent indicated no potential vulnerabilities. Of those who did indicate problems, 8% expressed concern over alerting difficulties arising at night, 4% during the weekend, and 1% during evenings, nights, and weekends.

Overall, if the right person is called, most communities can be notified on a 24-hour basis. For a few, however, delays can occur while the community officials are contacted should the emergency occur at an off-hour.

*How well established are communication procedures?*

Once a community's point of contact receives an alert, it sets into motion, in many cases, a notification process within the community. Seldom will the per-





son receiving the notification have or solely take on the authority to issue a warning to the public. The ability to provide an effective and timely warning will be shaped by the efficiency of the community response to the initial notification.

A major factor which determines the efficiency of the process is knowledge of what to do following the alert (Barton, 1969; Brouillette and Quarantelli, 1971; Drabek et al., 1981; Kreps, 1978; Stallings, 1978; Warheit, 1968). Such knowledge may be reflected by a well-articulated description of the steps to be taken or by having a standard operating procedure to follow after the notification. Unclear knowledge, or even worse, no knowledge, of what to do will delay or impede an effective warning.

Communities were, therefore, asked to describe the procedure they would follow after receiving the alert. All but 4% described a procedure. The remaining 96% were coded as to whether the procedure was clearly specified or part of a standard operating procedure (SOP); or whether it was described in vague generalities. Examples of a vague procedure would be "we would contact someone at city hall", or "we would send someone to see what was going on". An example of a clear procedure would be "we would call people on our notification list or backups in the order specified and activate the EOC where these people would gather to assess the situation". Of the 96%, about half of the communities were judged to have clear procedures and half had vague procedures. Since 65% of the communities indicated they had a written warning plan or procedure (although many did not provide evidence of this), we can interpret this to mean that some of the communities may not fully understand the contents of the plan or were poor in communicating the contents. Both are potential communications problems in an emergency.

*What information is needed?*

An alert from the facility needs to be accompanied by a notification, the 'contents' of a warning. To make a timely warning decision, public officials will need to know more than that an emergency exists (Anderson, 1969; Dynes, 1970, 1978). In addition, the warning to the public must contain the 'who-what-when-where-why' of the situation, as well as other relevant content. Therefore, we asked the communities what information they needed from the facility to make a warning decision.

The most common and frequently cited item of information needed by the community is the type(s) of chemical(s) released or involved (79%). The next most frequently requested information is the size or amount of material released (57%) and human health risk or danger (42%). Relatively few community officials indicated a need for information on location of the plume or release (37%), speed of dispersion (24%), potential pathways (24%) or protective-action recommendations (20%). Still fewer local emergency authorities indicated facility response or what the facility was doing to control the event (13%) or whether community assistance was needed (13%). Many officials, however, expressed needs in a general way (e.g., what happened). Overall, community representatives cited 3.7 items of information needed on the average.

These results require cautious interpretation; nevertheless, they are revealing. The need for caution stems from the difficulty attendant on asking people to envision and list on a questionnaire, what they would want in a hypothetical chemical accident of a general nature. Second, respondents may have assumed a general response subsumed all of the more specific items.

Even taking such points into consideration, however, we are still left with the conclusion that many communities do not know what information to ask for in an emergency. Even if one assumes that eventually the person in the response organization who does know the right questions to ask takes over communications, a delay will have occurred in getting the essential facts.

Several communities have prepared notification sheets for the receiver of the initial alert to request relevant data. In such cases, communities requested most, if not all, information contained in our specific categories, and some communities requested additional data. Such sheets help ensure timely receipt of relevant information and a written record of what is received. However, this is not the case in most communities, although there is a continuum in the amount and type of information requested.

## How reliable is the community decision-making process?

The next stage of the alert process is for the community to decide whether or not to issue a warning to the public. This may entail not a single decision but a series of decisions regarding precautionary warnings, warnings to take protective actions; announcements that the situation is not hazardous, or notifications that the emergency has ended. The most problematic warning is for people to evacuate, shelter, or take some other form of self or group protection. In this section, we examine the authority and role of issuing warnings, the length of time to do so, the types of protective actions that would be considered, and the procedures for making a decision.

### *Authority*

The state holds the authority to issue emergency warnings to its citizens in the face of disasters. Most states delegate such authority to municipal and county governments. That delegation means that the authority to issue a warning is typically assigned to an individual or set of individuals in local government. Clear definition of authority is associated with an effective emergency response (Dynes, 1969; Form and Nosow, 1958; Thompson and Hawkes, 1952).





In most communities, the people with that authority are identifiable by either name and position (67%) or by position (30%). In 2% of the communities that authority was unknown. In most communities, the person with authority is also the person with the assigned responsibility of issuing a warning (79%). In 7% of the communities, no one has been assigned specific responsibility. In 13%, that authority has been assigned to a person other than the one with legal authority. If authority is unclear or not assigned, warnings can be delayed while such authority is established. In most cases, this does not appear to be problematic.

### *How long does it take to decide?*

The length of time it takes to decide to issue a warning is variable, depending on a host of factors. Critical ones include how long it takes to mobilize decision makers, how many people are involved in the decision, how long it takes to reach a decision, and the urgency of the situation. The last factor seems to be critical; emergency systems can accelerate the speed of operations when a severe crisis is apparent. Conversely, when time allows, decisions proceed at a slower pace.

One way things accelerate in an urgent situation is through involving fewer decision makers. For coping with a fast-moving release of chemicals, communities indicated a need to invoke an average of two decision makers. For a slow-developing emergency, that number expanded to an average of five. A fast-moving event frequently required only one person to make a decision.

To gain a rough estimate of the time it takes to mobilize decision makers, we asked community officials to estimate a minimum and a most likely mobilization time to assemble decision makers in both slow-moving and fast-moving events. Whereas the estimates do not provide highly valid time estimates, although the means are within ranges established in actual emergencies, they provide an indication of the effect of urgency on the time of warning dissemination. People could be assembled in roughly one-third less time if the situation warranted. In addition, the minimum times were about 50% lower than the most likely. Similar relationships are also observed about estimates of decision-time, that is, once together, the time it took to reach a decision to issue a warning.

On the whole, the average time estimated to arrive at a warning decision under ideal conditions given a fast moving event was 18.4 minutes. A most likely estimate, reflecting conditions that would interfere with mobilizing and decision, had a mean of 30 minutes. Those expand in slowly developing events. The estimates reflect that many communities are capable of making timely decisions, although a timely decision is not guaranteed even when the situation warrants one.

*What actions will be recommended?*

Protective actions are the range of actions people can take to reduce exposure to the hazard in an emergency. For chemical emergencies, the action most often practiced is evacuation. Another major option is sheltering in a structure, often with enhancements such as taped windows and doors or alterations in the ventilation system. Other protective actions, not usually considered as such, include respiratory protection, skin protection, positive pressure shelters, decontamination, antidotes, and prophylactic drugs.

Protective-action recommendations are an important part of the notification procedure. The public expects guidance on what to do, not merely being told about the danger. When more than one protective action is considered, delays may occur in the decision process. On the other hand, when only a single action is considered for all situations, that action may not be an effective means of protecting the public under all accident scenarios.

Communities were asked what protective actions they would consider for the general public and for institutions in a chemical emergency. For the general public, a slight majority of communities (54%) recognize both evacuation and some type of sheltering. Many would consider only the single action of evacuation (32%) and to a much lesser extent shelter (4%). Ten percent of the communities have not developed or are in the process of developing protective-action strategies.

A similar pattern emerges for institutionalized populations. More communities (11%) viewed sheltering as the only option for institutions as opposed to the general population. Evacuation as a sole strategy diminished in appeal but still remains significantly large (26%). Evacuation or sheltering is the most popular strategy although many indicated a philosophy of shelter first and evacuation in extreme conditions.

Overall, the use of sheltering as a protective-action strategy is not as widely perceived as a viable option when compared to evacuation. Many communities are geared to an evacuation-only philosophy; fewer espouse a shelter-only policy. Such policies reduce the problems in decision making but may increase the threat to people in the emergency.

*How well established is the process?*

The need for a procedure for making public alert and notification decisions follows the same logic as for the initial notification response. Clear and understood procedures lead to more timely and effective decisions. Respondents were asked to describe the procedure. Again, their responses were coded as having no procedure, a vague procedure, or a clear procedure. An example of a vague procedure would be "we would evaluate the situation". An example of a clear procedure is "the mayor would consult with the fire chief and the plant manager and if the plant manager thought that a release would get off site, we would issue a warning".





The results indicated that 32% of the communities have clear or standard procedures for making a warning decision. Only 5% did not describe a procedure. The remainder specified rather vague procedures. This is consistent with another finding that 39% said they had a written procedure or plan for making a warning decision.

The lack of written or at least clearly defined procedures in the majority of the communities points up another constraint to effective and timely public alert. The deficiency is not a showstopper, but it increases the probability of a warning system failure or a delay in issuing the alert.

**How will the public be notified?**

Providing emergency information to and notification of the public of a potential danger is the primary objective of public-alert systems. Disseminating emergency alert and notification to the public in the event of warning emerges as the leading problem facing emergency managers in the communities; 44% mentioned some form of public alerting when asked to identify the "weakest link" in getting information to the public.

Because the emergency-response problems differ for various population groups, the warning systems and the warning requirements vary among different groups. People in close vicinity, — say, within a mile — of the facility require prompt warning of emergencies, whereas prompt warning is less critical for people within 5 miles, even though rapid warning is still necessary. Institutional and transient populations face quite different warning problems, complicated by problematic mobility and susceptible populations in the case of the former, and unfamiliar, special, or extraordinary circumstances in the latter. Warning systems also have to account for the tremendous variation in the location of people at various times of the day and days of the week.

*Warning systems*

Warning systems may be characterized as three basic types with subclassifications as follows:

*Enhanced systems:* Use sirens and some form of specialized alerting such as tone alerts.
*Siren-based systems:* Rely on sirens for alert with use of media-based notification.
*Ad hoc systems:* Rely on media and EBS and door-to-door or route alert.

Enhanced systems are capable of fast alert and fast notification of those with specialized alerting equipment. Siren-based systems have the potential for fast alert (based on coverage) with notification being more problematic (Lachman, Tatsuoka and Bonk, 1961). Ad hoc systems require more time to implement and to reach the public with a message.

Yet ad hoc methods are the predominant means (45%) of warning people in close proximity of the chemical facilities. Sixteen percent of the communities report relying on route alert or door-to-door notification. Another 29% would rely on an emergency broadcast system (EBS) or media warnings. Siren-based systems are utilized in 33% of the communities. Twelve percent of the communities use enhanced systems that involve both sirens and tone-alert radios. All of these systems would be effective in an emergency with a 3- to 4-hour lead time or to support a precautionary response. In a rapid-moving event, however, the majority of systems, including siren-based systems, are unlikely to provide an effective warning. In the 5-mile radius, a slightly greater reliance is placed on ad hoc systems and a lesser reliance on sirens or tone alerts. Although more time exists to alert the more distant population, the ability to issue quick alerts is similar to that in the 1-mile radius.

The use of tone-alert based systems as well as telephones increases for institutional populations. A lesser reliance is placed on ad hoc or siren systems. Nevertheless, about one-half of the communities use conventional systems. Tone alerts are used in 18% of the communities. Institutions need special warnings to allow extra time to implement protective responses. Many do not have that extra margin of safety. Twelve percent of the communities have no provisions to warn institutional populations. Transients are largely ignored as a group requiring warning. Eighteen percent of the communities have no system in place for warning nonresidential/noninstitutional populations. The majority rely on ad hoc or siren-based systems to warn transients.

*Source of emergency warnings*

Multiple sources of warning (Mileti and Sorensen, in press) and officialness of the source (Baker, 1986; Drabek, 1969, 1983; Perry and Mushkatel, 1986; Perry et al., 1981) add credibility and believability to the warning message. Because the credibility of a warning message and warning belief are crucial in the determination of public response to emergency warnings, the identification of the source of the warning information is a critical element of the warning process. Emergency warnings are more likely to be effective when there are multiple sources of warning indicated, and local authorities, political as well as technical, are associated with the warning message.

The civil defense or emergency management official is the most frequently reported source of warning information (83%). Additional emergency-management public-safety people reported as sources of emergency warnings include: the fire chief (74%), the police chief (60%), and the sheriff (46%). The most frequently mentioned manager or political official reported as a source of the warning is the mayor (53%), followed closely by the chemical facility manager (47%), then the county executive (40%), the city or county manager (31%), and state officials (28%). Sources of warning information who would qualify as technical experts include public health officials (27%), a scientist or engineer from the facility (22%), and government scientists or engineers (7%). An additional 3% report no one would be identified as the source of the information, and 10% report other sources.





The people in charge of the emergency, at least in its initial phases, are well represented as sources of warning information. This tends to achieve what might be termed the "situation credibility", that is, the existence of an element of understanding about the current situation. "Authority credibility" establishes who is in charge and helps determine why people should listen to an emergency warning that is not as developed as it should be. This kind of credibility is associated with local government officials, who are represented less predominantly than emergency officials. The most under-represented sources of warning information are the technical experts, who establish the "technical credibility" or public confidence in the accuracy of the warning message. Warning messages are likely to be most effective when all three sources of warning are firmly established.

About 20% of the communities would use a single authority as the warning source. Forty percent would attribute the warning to political or management personnel, such as the mayor, facility manager, city and county executives, or state officials. At least one of each type of authority is reported by 36% of the communities in the survey. Whereas 12% of the respondents reported multiple people in each category of warning-source credibility, they tended to overidentify emergency managers and political or management positions as sources of warning and to under-represent technical information sources. Emergency managers cannot issue emergency warnings under a simple "stimulus-response" model of public reaction and thereby achieve effective emergency response. These three kinds of warning credibility are established by specifically identifying these kinds of people as sources of emergency warning. Public response to emergency warning can be significantly improved by establishing warning-message protocols that clearly identify warning sources and by establishing public confidence via enhanced situation and technical credibility as well as credible authority in warning messages.

*Warning preparedness*

Preparedness is partially represented by having plans and procedures, as well as "priming" the system. The ways of priming include tests and public education. Preplanned messages are also a sign of preparedness. Warning equipment is tested on a fairly routine basis, with most reporting such tests on a weekly (32%) or monthly (26%) basis. Some communities (13%) even report testing of warning equipment and procedures on a daily basis, but 19% report testing warning equipment and procedures less often than monthly.

In addition, 10% report no testing at all. Written protocols for communications with the general public, via the EBS or the media, have been prepared in 33% of the communities in the survey, and protocols for institutional facilities are available in less than one community in five (19.7%). Few communities have protocols for foreign-language populations.

Despite a scarcity of evidence that public education makes a difference as to whether a warning system will function effectively, most agree that it contributes to an effective response. The majority of communities have in place either no public information program or a poorly developed one. Only 19% described a program with multiple activities. Another 21% had initiated a single activity, typically the preparation of a brochure. Of the 40% who described a specific program, however, only 15% provided evidence that a program actually existed.

## Conclusions

The current state-of-the-art warning system for a chemical emergency must be able to provide both an alert and notification in a short time frame due to the potentially rapid speed at which a chemical can be dispersed. The state of the art in facility-to-community alert would involve the use of an automated alarm with a dedicated telephone line or a tone-alert radio/pager system. Both would require some form of backup such as a 911 emergency system and two-way radio.

The current state of the art for public warning depends on the public's proximity to the facility. For people in close proximity to the plant (within 1 to 2 miles) the state-of-the-art system would involve tone-alert radios or a telephone dialing system coupled with a siren and emergency media message dissemination. For more distant populations (5 miles), any one of those three technologies is likely to be adequate.

The state-of-the-art management practices are more difficult to define. Although plans are not a prerequisite or guarantee of effective response, they are positively associated with better responses. As such, the clarity and presence of plans are indicators of the quality-management practices.

Few communities in the study used state-of-the-art communication equipment or warning-system technologies. It is clear that some communities do not need such equipment because the most likely risk does not justify the expense. In other communities the differences are more critical due to more severe threats and a larger number of people and institutional facilities at risk. The overall capacity of the majority of systems to provide a timely alert and notification is questionable, particularly in a rapid-onset event.

With respect to management practices, few communities had well-developed plans and procedures to guide emergency response. Notably lacking were capabilities to make decisions. Both lack of procedures and, more basically, insufficient knowledge about what information is needed to make a decision.





suggest major problems with issuing a timely emergency warning. Also lacking were preplanned warning messages and public information programs.

The preceding data and other related studies (Quarantelli, 1981, 1984) yield the following conclusions about improving community preparedness for potential fixed-site chemical accidents. These are ordered within the four categories with respect to the priority of each recommendation.

### *Technology*

(1) Improved communication technologies between facilities and communities with additional backup capabilities would reduce the uncertainty about timely notification.
(2) Improved public warning technologies in high-risk and densely populated areas would increase the likelihood of a fast and effective warning.
(3) Better communication links between community EOCs and institutionalized populations would help insure timely notification of populations who require more time and special protection in emergencies.
(4) Adoption of computerized emergency-planning and management systems and decision aids is likely needed to manage an emergency in a more effective way.
(5) Improved communications equipment within community emergency response organizations would strengthen decision making in fast-moving events.

### *Procedures*

(1) Use of a standardized information protocol to guide community information collection and dissemination following the initial notification from the facility would improve community decision making.
(2) Adoption of SOPs for initial response to alerts, for making decisions on warnings, and for recommending protective action is needed to systematize response.
(3) Adoption of state-of-the-art warning-message protocols for both English and, where needed, non-English-speaking populations would enhance the quality of the notification process.

### *Management Practices*

(1) Implementation of exercises in communities not conducting exercises and more frequent exercises in other communities will serve to improve coordination of response.
(2) Improving the working relationships between personnel at the facilities and officials within the community emergency-response structure is needed.
(3) Developing and implementing improved public information programs would foster public understanding of chemical emergencies.

(4) Improving the organizational interface and coordination among federal, state, and local planning agencies would help insure the quality of local planning.

*Technical information*

(1) Studies of public response to warnings in chemical emergencies are needed to improve warning-system design.
(2) Better technical information on sheltering would facilitate the making of decisions regarding protective action.

The methods of achieving improved practices are varied and require careful consideration. Among the possible mechanisms are improved planning guides, new training courses, video conferences, seminars, workshops and working through existing programs such as the chemical industry's Community Awareness and Emergency Response (CAER) to develop improved planning and management practices.

The improvement of public-alert systems is feasible without the development of new technologies. The problem of diffusing existing technology and knowledge is greater at present than the problems created by the lack of appropriate technology. Unless new technologies led to low-cost equipment that could rapidly alert and notify the public, and was easily installed and maintained, further technological advances would only increase the gap between practices and the state of the art.

At a local level the feasibility of improvement relies on two factors. The first is the dissemination of information on low-cost or no-cost improvements. This includes improving procedures and management practices. Major improvements in management practices and procedures can be achieved without major expenditures.

The second is providing funds for improved communication equipment and warning system equipment. It is unlikely that communities have the funds to install new communication devices or completely new warning systems. Improvements in these areas will require assistance to the communities or cost sharing.

At this point, it appears that the improvement of management practices and the development of better procedures to make decisions and to initiate the warning process are more critical than the promotion of better technology, albeit both are important. The most sophisticated equipment is relatively useless unless it can be used properly. Some redressing of the poor communication and the lack of decison-making capabilities among decision makers is a prerequisite to implementing state-of-the-art technology.

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# Individual, Group, and Organizational Decision Making in Technological Emergencies: A Review of Research

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## Abstract

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Emergency-response systems for hazardous technological emergencies are generally comprised of a number of organizations with varying degrees of control over information and resources. The implementation of such systems and the need for coordination impose various conflicts on decision makers and response personnel. Using the example of nuclear power plant accidents, four critical categories of performance-shaping factors that can enable decision failures are identified: structural, affective, informational, and task and resource characteristics. A review of individual, group, and organizational decision-making literature suggests that many such factors may have important negative influences on performance. The role of training and exercises is discussed as a means for improving emergency-response system effectiveness and reliability.

## Introduction

Emergency-response systems for hazardous technological emergencies are generally comprised of a number of organizations with varying degrees of control over information and resources. The implementation of such systems and the need for coordination impose various conflicts on decision makers and response personnel. Conflicts may result from tensions between flexibility and the control of information and resources, between timing and effective decision-making strategies, and between the use of expertise and the timing of decisions. The novelty of emergency situations and unrealistic or absent training for real emergencies also further constrain the behavior of personnel.

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