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Community Decisions During Chemical Emergencies

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ABSTRACT

Actions taken to protect the public from airborne chemical releases are limited by the timing of the implementation and capacity of those actions to avoid or reduce exposure. This paper focuses on community decision processes during emergencies to identify critical factors associated with the timing of emergency warning and protective action recommendation. This research traces emergency response from the outset of the community decision process, through the decision to warn the public, including the communication of hazard to the public, and the all clear at the end of the emergency period. Authorities and the public cycle through hazard detection, assessment, communication and behavioral response as they become award of the hazard.

A sample of community decision processes was examined via post-emergency interviews with key community officials in a randomly selected half of the significant chemical emergencies occurring during 1990 and a systematic sample of events after 1984 but prior to 1990. The community decision process is seldom immediate and often involves information seeking. When potential errors in judgement can lead to public injuries, officials seem to take evasive action more quickly, but when the errors in judgement can result in continued inconvenience, the decision process is often protracted.

INTRODUCTION

Since 1985, more than 100 chemical releases a year in the United States have required emergency operations involving community decisions and public response to protect people (Fig. 1). This averages an event requiring protective actions at the household level every 2 to 3 days.

The effectiveness of actions taken to protect the public from airborne chemical releases is limited by the timing of the implementation and the ability of those actions to avoid or reduce exposure.[1] The timing of implementation depends upon the facility and community organizations becoming aware of the hazard, assessing its severity and selecting an appropriate course of action to protect the public. A variety of factors expected to potentially influence the community level decision process includes the extent of emergency planning, the uncertainty associated with the release of hazardous chemicals, conflicts among decision-makers arising from the associated uncertainty and the community context of emergency operations and preparedness, which might be characterized by available resources, population segments to be protected and prior experience with similar incidents. The timing of the implementation of appropriate protective actions also depends upon the dissemination of emergency warning, the public response to the emergency warning(s) and implementation of the selected actions.

The ability of protective actions to avoid or reduce exposure depends on the "structural" capacity of the prescribed actions and the ability of the people to implement them. For example, evacuations can be completed in a duration that depends on the structural capacity of the road network, but they require that people are either capable of driving or that sufficient transportation be available to evacuate the impacted area.

This paper focuses on community decision processes during emergencies to identify critical factors associated with the timing of emergency response and the initiation of protective actions undertaken by the public. The timing of this "chain-of-activities" is critical in determining the effectiveness of protective actions.[2-4]

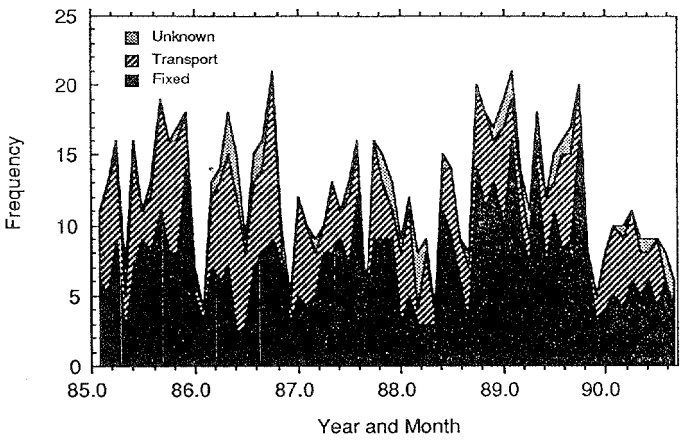

Figure 1
Frequency of Chemical Accidents by Year and Month

At the extreme, if the public is not warned, they cannot be expected to respond; if the public fails to understand the warning message in terms of what is expected of them, the response is likely to be ineffective. Effectiveness is the result of multiple factors including the complete warning process from recognition of hazard to the decision to warn the public, the associated message that establishes both the extent of the hazard and what protective action(s) are appropriate to avoid harm. Effectiveness is also impacted by the receipt of the warning by the public, its interpretation through the attachment of meaning to the message and each household's decision to respond in the identified manner.

BACKGROUND

The human systems associated with the communication of emer-

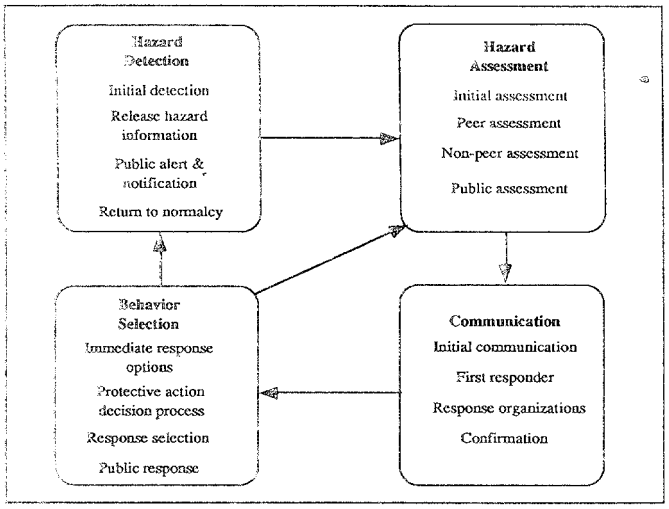

Figure 2
A Summary of the Cyclical Nature of Emergency Warning
(Source: Rogers[15])

gency warning are cyclical,[4] with people beginning the process with some form of detection and cycling through hazard assessment, communication and behavior selection (Fig. 2). The cyclical process allows people to assess and re-assess the hazard, communicate with others regarding appropriate actions and select behavior to protect people from harm.

The timing of emergency decisions in chemical emergencies determines the effectiveness of actions taken to protect the public to a large degree.[1] Thus, for any protective action to achieve its design effectiveness, people must become aware of the potential for harm, decide to act and take the appropriate actions to protect themselves. Important elements of that process include the community's decision to warn the public and the public official's recommendation regarding appropriate protective action. This research addresses these two important decisions by community officials. Interorganizational decisions broaden both responsibility and perspective, which tends to make decisions more effective. Small group decision theory suggests that generally the larger the group, the longer it is likely to take to make decisions.[5] Because interorganizational decisions involve more people, they are likely to lengthen the time it takes to reach a decision. This research examines the interorganizational decisions in terms of the balance between the number of people representing those organizations and the time it takes to make emergency response decisions.

Experimental research on cognitive processes of decision-making indicates that a variety of problem simplifications occur at the individual level that bias judgements.[6-7] Based on psychometric studies, Kahneman and Tvesky[8-9] have even shown that people will reverse their choices of risky alternatives when equivalent alternatives are presented as a choice between a sure gain and a gamble, versus a sure loss and a gamble. Judgmental heuristics have also generated controversy over the assessment of public preferences for risk. People make initial estimates of numbers resulting from complex processes that are often at the heart of response to technological risk and then adjust them to arrive at a final answer. This anchoring effect can bias risk choices when artificially high or low starting points are used.[9] These kinds of judgmental heuristics present challenges to a rational decision-making model.[10]

In a free society, any time more than one person is involved in decisions, differing points of view are possible and these views can lead to various kinds of conflict with different functions.[11] Intraorganizational decisions during emergency have been examined, but limited research on intraorganizational decisions exists.[12] This research focuses on intraorganizational decisions made in response to chemical emergencies during the crisis. The direct impacts of the emergency situation on the community decision process are examined[13] rather than the public response process.[14-18]

The community decision process is examined during the emergency period, beginning with the recognition of hazard and continuing through the all clear.[13] This research focuses on the key decisions reached during this period, including the recognition of hazard, its assessment, the decision to warn the public, the selection of an appropriate protective actions and the reassessment of hazard leading to an all clear.

DATA AND METHODS OF ANALYSIS

In order to collect data from people who can report effectively on the conduct of emergency decisions during an emergency involving protective actions taken by the public, the data must be collected while the events remain clear in the minds of the participants. Hence, this involves a two-step process of identifying the events in the universe and interviewing a sample of selected community officials having recently experienced an event. To assure the latter, the sampling universe was iteratively generated, with interviews conducted within 2 to 3 wks of occurrence of the event.

The universe of events was identified by conducting periodic searches of NEXUS listings of the Associated Press/United Press International news stories involving the evacuation (or other protective actions) of 10 or more people as the result of chemical accidents or events.[19-20] These events are of sufficient size to require more than a single household's response and would thereby require decisions by public officials during the event.

Key community officials representing organizations vital to the community's emergency response were interviewed. The person responsible for reaching critical decisions was interviewed, as well as people with a direct role in emergency decisions when necessary.

These interviews focused on the timing of critical events in the emergency response, involvement of emergency response personnel in the decision process, examination of protection alternatives, the emergence of viable protection alternatives and the resolution of any resultant conflict among personnel involved in the decision process.

Initial interviews consisted of 14 cases that had been previously examined regarding the use of in-place sheltering techniques in response to chemical accidents resulting in vapor clouds. These cases were used to refine the sample selection, interviewing, and coding processes. Because of the enhanced recall associated with more recent events and the lack of confounding from other events occurring between the qualifying event and the interview, it became evident during the pretests that more reliable data would result by reducing the time period between the event's occurrence and the interview.

In September and December 1989, 10 cases were selected to pretest the interviewing guide to interview community officials associated with all events occurring in these months. Sampling all events sometimes resulted in interviews being conducted long after the event, yielding sometimes questionable data. A simple random sample of all qualifying events occurring in 1990 was drawn. This sample resulted in 51 events (communities) being selected for study. Data regarding community response to 70 events were collected in all.

Data for events in each community examined the decision process in terms of three primary decisions: (1) the "decision to warn" the public of impending danger, (2) the selection of an appropriate "protective action" and (3) the decision to issue an "all clear." The decision to warn involves all the activities beginning with the first awareness of an event until the warning system is activated. These activities can include the initial identifications, location and assessment of the hazard, the communication of this hazard to a decision group, the discussion of alternative responses to the existing hazard, which can give rise to conflict, and the resolution of that conflict, and the implementation of that action.

The protective action decision involves the selection of appropriate action (s) to be taken in response to the event. While it is often explicitly or implicitly imbedded in the decision to warn, it is also frequently considered separately. For example, it may become clear very early that the public will have to be warned, but it may remain less clear as to what to tell the public to do in response to the event. The all clear decision involves monitoring or reassessing the hazard

as it progresses to determine then the danger associated with the event no longer exists. Data concerning the timing of a number of key events in the emergency were reported. These key events include the time of the incident, the time the decision to warn was reached, the time the protective action was selected, the time the warning began and ended and the time an all clear was issued. Because these events mark the times at which decisions begin and end, the length of the decision process is attainable. Because the events and communities are not uniform, measurement is more difficult. For example, some communities merged warning and protective action decisions; other events and communities required multiple warnings and decisions regarding a staged response. The timing of response decisions is operationalized as the additional time required to reach the next decision in the process, beginning with the decision to warn, followed by decisions about protective actions and concluding with an all clear decision. The most clear timing is the decision to warn (DW):

$$DW = (DW_t - I_t + d) * 60 \quad (1)$$

where DW_t is the time of the decision to warn the public in hours since midnight, It is the time of the incident in hours since midnight and d equals 0 if DW_t and I_t occur in the same 24-hr period and 24 if they occur on consecutive days. Multiplying by 60 converts the measure to minutes. Measurement is less clear for protective action decisions, primarily because the time the decision begins is less clear. The additional time required for operationalization allows us to measure the time required for protective action decisions (PA) as:

$$PA = (PA_t - DW_t + d) * 60 \quad (2)$$

where PA_t is the time the protective action decision was reached in hours since midnight, and the rest are defined as above, except d = 0 if PA_t and DW_t occur on the same day and 24 if they occur on consecutive days. The beginning of the all clear decision is also unclear. Respondents frequently link the reassessment of the situation to events (e.g., the capping of a leak, the containment or suppression of a fire, the off-loading of remaining chemical or simply the arrival of an outside assessment team). This would indicate that once these activities are completed, officials begin to reassess the situation to determine if people can return to normal activities; however, this fails to account for the process of determining that the activity (e.g., containment, off-leading or fire suppression) is critical to the all clear decision. This study takes advantage of a fundamental fact: officials cannot consider issuing an all clear before they finish warning people of the impending danger. Hence, the time required to reach an all clear decision (AC) is measured as:

$$AC = (AC_t - WE_t + d) * 60, \quad (3)$$

where AC_t is the time the all clear decision was reached in hours since midnight, WE_t is the time the warning process ended (i.e., the time public officials stopped warning people of the impending danger) and the rest are defined as above, except d = 0 if AC_t and WE_t occur on the same day and 24 if they occur on consecutive days. Measuring decision times in this manner calibrates the timing of each event on the same scale and thereby allows comparison.

FINDINGS

The length of time required to make critical decisions during the community's response to chemical accidents varies considerably. The decision to warn the public took an average of 79 min, ranging from less than 1 min to more than 16 hr. There is only one change in 20 that the mean is not between approximately 40 min and 2 hr. Protective action decision took an average of 1 hr and 45 min, ranging from no additional time spent on protective action decisions to more than 24 hr. The 95% confidence interval around the mean is from approximately 1 hr 15 min to 2 hr 15 min. All clear decisions seem to take considerably longer, averaging 7.5 hr and ranging from less than 1 min to nearly 2 days. Approximately, one time in 20 the mean will be less than 5.5 hr or more than 9.5 hr. Figure 3 summarizes the timing

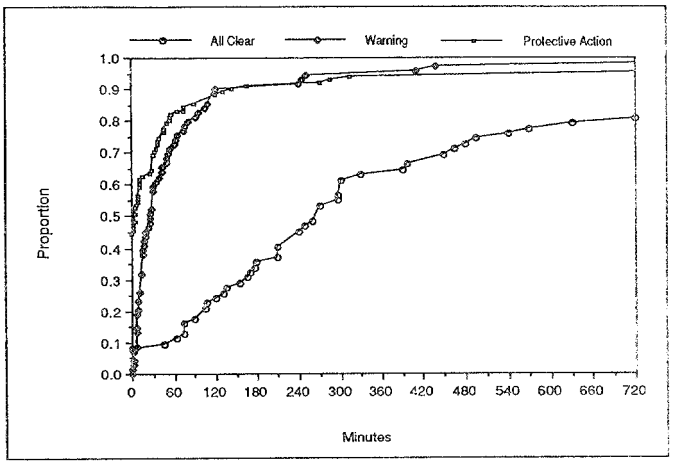

Figure 3
Timing of Decisions by Type

of community response decisions by type of decision in terms of the proportion having reached the decision by minute for the first 12 hr of the process.

One-half of the decisions to warn the public are made within 30 min, with approximately 75% being made in the first hour. Approximately 9 out of 10 decisions to warn the public are made within the first 2 hr. Because the protective action decisions are frequently incorporated in the decision to warn, approximately 45% of the protective action decisions contribute no additional time to the decision process. Approximately 70% of the protective action decisions are made within 30 min, with approximately 85% being made within the first hour, and just under 90% being made within the first 2 hr. While protective action decisions clearly occur most rapidly, given the time added conception, an all clear decisions generally use more time than either protective action decisions or decisions to warn the public.

Given the nature of the decision to warn and the selection of appropriate actions to protect the public, it seems evident that decisions directed at the attainment of protection are arrived at more quickly than decisions that may (if made incorrectly) result in exposure. Hence, "safe-side" decisions seem to be made more quickly than decisions that might put people at risk.

For a variety of reasons, the decision process is likely to take longer when more than one organization is involved in the process. Figure 4 seems to support this general conclusion; however, none of the differences of means tests, either taken jointly or individually for each decision type, are statistically significant. While the differences of means are approximately 30 min, the variances are too large for these differences to be significant.

DISCUSSION AND CONCLUSIONS

These preliminary data indicate clearly that the community decision process in chemical emergencies is seldom immediate. Because these decisions are not routine emergency decisions, handled daily by emergency personnel, and because chemical emergencies often involve the resolution of uncertainty, decisions in chemical emergencies often involve information seeking. Perhaps because chemical emergencies can involve blame, culpability and potential litigation, public officials are not entirely comfortable with information provided by industry representatives involved in the emergency; perhaps because these events are rare enough that standard operating procedures have not been developed for all local authorities (or uniformly applied nationwide); perhaps because the legal structure gives authority to undertake protective actions (e.g., evacuations) by the public to certain, often elected, officials; but for whatever reason, community decisions are not immediate, and they often take considerable time, often involving hours and sometimes extending to several hours.

Fortunately, when potential errors in judgement can lead to injuries, officials seem to take evasive action more quickly. As reflected in these

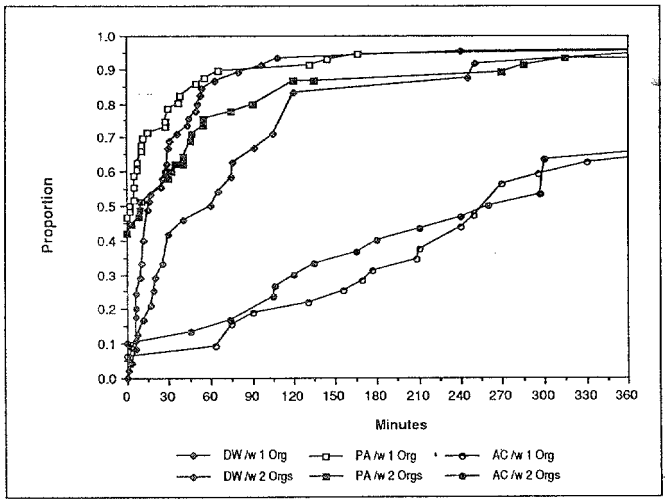

Figure 4
Timing of Decision by Type and
Number of Organizations

limited data associated with community decisions to warn the public and select protective actions, decisions that can result in an inconvenience of the public if in error, are more quickly arrived at than decisions (i.e., all clear) that can harm if made incorrectly. Hence, decision-makers seem to err on the side of caution, protracting decisions where errors in judgement can result in continued inconvenience, but shorten decision times when failure to decide can result in harm to those impacted.

There are a number of important issues for future research in this area, for example: the examination of the role of the leadership/power structure of the decision-making group; the examination of mechanisms used to resolve conflicts arising from differences among the decision-makers regarding the best alternative for protection; and the search for the optimal use of personnel in disasters (when should more people or organizations be added to the decision group, and when should people and organizations be excluded?). How can research get beyond the measurement problems associated with effectiveness, so that the concept includes both quality and timing of the decision?

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