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COMMUNITY AND ORGANIZATIONAL PREPARATIONS FOR AND RESPONSES TO ACUTE CHEMICAL EMERGENCIES AND DISASTERS IN THE UNITED STATES: RESEARCH FINDINGS AND THEIR WIDER APPLICABILITY*

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INTRODUCTION

There appears to be general agreement that the number of accidents, disasters and catastrophes involving dangerous chemicals has been increasing in the last decade or so. The Bhopal, India, incident was a public manifestation of what many observers have known has been a growing increase of problematical risky events in the chemical area.

Considerable technical research has been undertaken on the handling of hazardous chemical occasions. However, little attention has been given to the behavioral features of the problem, that is, the human and group aspects. To begin to close this gap in knowledge, the Disaster Research Center (DRC) in 1977 began a four year study of sociobehavioral preparations for and managing of chemical disasters. This study was the first systematic and large scale effort of its kind undertaken by social scientists.

In 45 field studies, DRC examined organizational and community preparedness planning for as well as the management of response to sudden dangers resulting from hazardous chemicals. In the first phase of the study, systematic and comparative data on preparedness were obtained from 19 communities in the United States that had varying degrees of risk due to dangerous chemicals. In the second phase of the research, DRC studied 26 management of responses to major emergencies or disasters that resulted from toxic releases, explosions, spills, fires, or other acute chemical threats.

The on-site data in both phases of the study, obtained primarily through intensive interviewing of key personnel and collection of documents, were subjected to a variety of quantitative and qualitative analyses, the specifics of which have been reported in publications elsewhere (e.g. Quarantelli and Tierney, 1979; Tierney, 1980; Gray, 1981; Gray and Quarantelli, 1981; Tierney, 1982; Gray and Quarantelli, 1983; Quarantelli, 1984a). In this paper a general overview is presented of these findings. We will first briefly summarize what we learned about preparedness planning for chemical threats. However, the bulk of the paper reports what DRC found in its studies of response management, with special attention being given to emergencies and disasters resulting from transportation accidents. More specific information about the methodology and theory, as well as different substantive foci of the study, is contained in the publications previously cited. A general report on the full study is given in Quarantelli (1984c).

Since that initial research, which was concluded in 1981, DRC has done additional work on chemical disasters. Two explosions were separately studied in field studies: (a) a chemical tank explosion in 1982 in Taft, Louisiana (Quarantelli, Phillips and Hutchinson, 1983), and (b) a major catastrophe outside of the United States: the liquified petroleum gas explosion in November 1984 in the Mexico City metropolitan area. In addition, for other purposes, a series of official reports on chemical incidents were recently systematically examined (e.g., the report on an incident in Somerville, Massachusetts, where in 1980 a cloud resulted from a spill of phosphorus trichloride as a consequence of a train accident; 418 people were injured and there was a forced evacuation of a 1.5 square mile area which contained 23,000 inhabitants). We also recently undertook a comparative analysis of transportation accidents that involve phosgene gas versus those that involve dangerous nuclear wastes (Quarantelli, 1982). Currently, as part of a series of field studies on organizational functioning in crisis occasions, DRC has also looked at seven more chemical incidents, including the phosphorous spill from a train derailment in Dayton, Ohio, in 1986 and another similar spill in the Pittsburgh metropolitan area. There later field studies and analyses have been used to test and to extend some of the observations and conclusions that were drawn from the initial large scale research. Thus, while this paper is primarily a summary presentation of the first systematic research, it does take later work into account.

RESEARCH FINDINGS ABOUT DISASTER PREPAREDNESS PLANNING

Threat Perceptions

There is a degree of perception that chemical agents, compared with other agents, have more potential as disaster agents. However, different communities, sectors, and organizations selectively vary in their perceptions of chemical threats (Helms, 1981). In particular, there are noticeable differences between threat perceptions of public and private groups, with the latter seeing chemically based disasters as less likely than the former. This variability in perception may partially be the result of role expectations as they apply to these different sectors of the community. That is, many public sector groups (such as fire departments) have official responsibility for emergency preparedness and are expected by the community to carry out these responsibilities. This type of role expectation can sensitize these groups to the various demands of their domains. On the other hand, fewer private sector groups (with the exception of chemical companies) have formal responsibility for preparedness planning and, therefore, are less likely to be aware of disaster threats in general.

Availability and Mobilization of Resources

In principle, but not in fact, there are many potential resources available to prepare for chemical emergencies and disasters. Many tangible resources either are unknown, are unrecognized as such, or are the property of private groups, and even when available tend to be segregated inefficiently from other kinds of community disaster resources. More intangible resources are also undependably and unevenly available, and a lack of leadership and responsibility for their availability prevails, particularly in the public sector.

There is little collective mobilization of resources except in a minority of communities with local comprehensive mutual aid systems (i.e., networks of relevant organizations from both the public and private sectors that form for the express purpose of sharing resources in disaster preparedness and response). Such systems are particularly strong with respect to resource sharing and communication, although they are usually weak in risk assessment, in providing a role for the medical area, and in addressing the problem of evacuation (Gabor, 1981). Extra-community resources are seldom part of any individual or collective preparedness planning for the mobilization of resources for chemical disasters.

Patterns of Community Social Organization

A variety of social linkages were found (i.e., formal or informal contacts between and among organizations and groups) for chemical preparedness planning in most of the communities we studied. In particular, there tend to be links between local fire departments and the chemical companies in their areas. The general pattern, however, is one of weak vertical rather than horizontal linkages within communities. That is, the structure tends to be hierarchical in nature, with authority vested in the uppermost levels and with few provisions for effective cross-communication among the various disaster relevant groups. There is also an almost total absence of local extra community linkages, even though the collective resources of the latter sources are extensive in nature. More integrated linkages are slowly evolving, but overall evidence shows a pattern of weak community social organization for chemical emergencies and disasters.

Social Climate

As a whole, the social climate in most local communities in the United States is not favorable to preparedness planning. While some of the existing norms, values, and beliefs provide incentives for planning, most do not. There is a tendency to believe that communities could respond to emergencies and disasters better than they probably do. This reinforces a disinclination to disturb local economic benefits from chemical plants or to argue against what is seen as a public unwillingness to spend governmental funds for most anything, including disaster preparedness planning.

The Planning Process and Preparedness

Only a low degree of preparedness planning for chemical emergencies and disasters exists in most communities in the United States. In fact, such planning is frequently nonexistent among public emergency organizations, with the exception of some fire departments. Preparations for chemical disasters are especially handicapped by the public-private sector split in the United States. An additional impediment to local planning efforts is the fact that the most relevant resources rest in the hands of extra community groups (i.e., state and federal level organizations), rather than with the local community organizations that invariably are confronted with problems associated with the immediate post-incident response.

Preparedness is often incorrectly equated with formal disaster plans, an end product of the planning process, or viewed as an extension of everyday operations. However, good preparedness is actually a knowledge-based, realistic process stressing general principles aimed at reducing the unknowns in a problematical situation. As such, it comprises all the activities, practices, documents, formal and informal agreements, and associated social arrangements that, over the long or short term, are intended to reduce the probability of disaster and/or the severity of the community disruption occasioned by its occurrence.

Community disaster preparedness for chemical problems is generally poor, if not nonexistent, in most localities. However, the private sector is relatively well prepared, especially for in-plant accidents. Extra community groups that do have resources for chemical crises are seldom incorporated into local planning. Nonetheless, to the extent that preparedness planning of any kind exists, it tends to make for a better response to chemical emergencies and disasters.

We should observe that while the above observations reflect our field studies in the last decade, much is happening with respect to chemical disaster preparedness planning in the United States in the last few years. Partly triggered by the Bhopal catastrophe, both the chemical industry and United States governmental agencies have initiated a variety of programs aimed at improving local community preparedness for chemical accidents and disasters. The effectiveness of this planning and its contribution to the better management of hazardous chemical incidents has not yet been documented. Almost certainly this preparedness planning will make the situation better than it was; however, we would suspect that what we report from the past will generally be what will be found in future studies. In the disaster area, as most other areas in life, improvements tend to occur incrementally and slowly, not massively and quickly.

RESEARCH FINDINGS ABOUT MANAGING RESPONSES TO CHEMICAL DISASTERS

Fixed and In-Transit Sites

There were some major differences in the patterns of response to hazardous chemical incidents that occurred at fixed sites compared with those that resulted from an accident that occurred while a vehicle was in transit. Fixed-site situations generally are those that occur in chemical plants or on their property. In-transit incidents are the result of transportation accidents, such as those that involve trucks, trains, barges, or aircraft carrying hazardous chemicals, and that occur on publicly accessible lands. Which organizations participate in the response to the crisis and what they do, as well as the difficulties that emerge, differ somewhat in the two types of situations.

Although there are many common elements between the two types of crises in the United States, there are enough differences in the responses to make them worthwhile noting. For example, emergencies that occur at a fixed-site, such as a plant, are likely to involve only company related groups, such as the plant fire squad, rather than the fire department of the local community. In contrast, in-transit accidents will, usually quickly, evoke the appearance of community emergency agencies, such as the local police and fire units. Fixed-site incidents, such as those that occur at a plant, usually generate responses that are specific to the particular chemical hazard involved. In-transit accidents, on the other hand, often initially trigger general accident response measures rather than specific chemical disaster responses. Also, in-plant chemical emergencies tend to lead to actions to contain, if not to prevent, the threat from developing. In contrast, many of the initial activities in in-transit accidents are devoted to measures to protect the community.

The differences in the managing of the two types of crises are the result of a variety of factors. Chemical plant incidents in the United States almost always occur on private property. In contrast, in-transit accidents, even though they may involve a private carrier, usually occur in what normally is viewed as a public setting. This is related to the low social visibility of incidents that occur at plants. Unless the accident is of major magnitude, only the workers and officials immediately present in the plant may know that there has been a chemical mishap. Although incidents beyond a certain level of impact are supposed to be reported to the public authorities, this does not always occur. In contrast, most (although not all) in-transit accidents are more socially visible; usually it is difficult to prevent the community from finding out about the accident. In our study we discovered some attempts to maintain secrecy about hazardous incidents in railroad yards; but most efforts of this kind were unsuccessful.

The major differences, however, between responses to fixed-site accidents and responses to in-transit accidents probably are the result of other factors. Chemical companies generally have good emergency preparedness programs, and the extent of preparedness is usually related to the size of the company. Larger companies are more likely to have detailed and extensive preparedness planning for chemical mishaps, especially if the plant is part of a nationwide or international corporation. There is a tendency to equate accident preparedness with disaster preparedness; however, even if an incident is an accident that is not a disaster, the mobilization of resoures to alleviate the accident will probably help alleviate the potential for a disaster occurring.

Moreover, not only is there likely to be less preparedness planning for in-transit accidents, but there are more problems that must be coped with in transportation related events. There are often complicated jurisdictional questions and multilevel organizational issues when trains, tank trucks, ships, or planes carrying dangerous chemicals are involved in a transportation accident. For example, any incident in the United States that may lead to the pollution of any body of water could lead to the activation of the national contingency plan for such events and the active participation of the U.S. Coast Guard, regardless of local and state plans and the activities of community and state agencies.

In summary, responses to chemically threatening incidents are better when the accident occurs in a fixed facility than when the accident occurs in transit. Often minor mishaps in chemical plants are so well handled that they never develop a potential for becoming a disaster. Also, when level of risk for an accident to occur is considered for different modes of transportation our study found that motor vehicle incidents are generally handled less efficiently and effectively than those occurring on railroads. In part this results from the relatively little systematic chemical disaster preparedness planning for accidents that occur on roads or highways; railroads have undertaken far more elaborate planning for chemical threats.

On the other hand, according to our study it appears that the potential for the occurrence of catastrophic chemical disasters compared with the potential for occurrence of noncatastrophic incidents is greatest in fixed installations. The next most vulnerable type of accident is that involving railroads. Motor vehicle incidents are least likely to result in catastrophic accidents. Our study did not obtain enough information to form a conclusion about the potential for the occurrence of chemical catastrophes as a result of barge-ship and airplane accidents.

There are many factors that can affect the magnitude of the possible danger in an incident. In general, it appears that the locations that have the greatest risk of occurrence of a chemical catastrophe or major disaster are those where better preparedness and response measures are likely to be found. That is, better preparedness for accidents generally exists in plants that produce the most dangerous and greatest volume of hazardous chemicals. Thus, it is in such locations that the quickest and most efficient initial responses to a chemical mishap are likely to occur in the United States.

First Responders

The importance of the initial response in a chemical emergency is widely recognized. One major American chemical manufacturer produced a safety training film entitled "Those Vital First Minutes" to emphasize the necessity of proper and quick actions during the period immediately following a chemical mishap or an accident that involves chemical substances. It is often the actions taken in the first few minutes, just before a release or just following a spill, that determine whether there will be a minor nonchemical mishap or the threat of or actual occurrence of a chemical disaster.

In incidents that occur inside chemical plants there usually is no lack of understanding that a hazardous chemical is involved. However, a far more problematical situation usually exists in the early stages of an in-transit mishap. We observed in the study that in transportation accidents first responders seldom initially perceive a dangerous chemical threat unless there are obvious sensory cues, such as a strong pungent odor or eye and skin irritations. This is true even when first responders are from emergency organizations such as fire or police departments. Motor vehicle or train accidents are initially seen only as transportation accidents or wrecks. The general tendency of first responders is to define the situation as it appears to be on the surface, namely a transportation incident. In doing this, responders are acting in a way that has long been observed in the disaster literature; that is, there is a tendency to consider all cues in terms of normal or expected events. If an occurrence appears to be a transportation accident, it will be perceived and defined as a transportation accident.

The problem with misperception of the initial situation is compounded in that organizational and community disaster plans rarely discuss the combination of a transportation accident and a hazardous chemical incident. A DRC content analysis of plans determined that separate consideration of the two types of events was almost universal. One consequence is a tendency for responding groups in transportation accidents to initially use their routine accident standard operating procedures; they seldom initially activate the disaster plans of their organizations and even more rarely do they activate the plans specifically for chemical disasters.

In principle, first responders should be aware of the various placards and symbols that are mandated by law in the United States to be carried on tanks and other containers of hazardous materials. Unfortunately, various studies have determined that the legal requirements are not always followed. One systematic study of trucks in Virginia found that 41 percent of the trucks stopped for inspection were violating placard requirements for hazardous materials (Schmidt and Price, 1977). It is stated in another unpublished report from a railroad, that its own study showed that required placards were in place on only 77 percent of the rail cars. The view that placarding requirements are often widely ignored is supported by the observations of our study.

However, even when placards and symbols are in place and readable after an accident, they are not automatically recognized. Our study revealed that first responders do not always note the signs that identify hazardous materials, and even if aware of them, they do not always fully understand their meaning. (This excludes situations in which placards and symbols had either been destroyed or were made illegible as a result of the transportation accident.) Also, first responders seldom have easily accessible manuals or booklets that would define the symbols or indicate how they should respond to the incident according to the type of dangerous chemical substance, identified by the placard, that is involved.

Sometimes first responders to transportation incidents do initiate searches for invoices or other relevant papers. However, even if a search is initiated, it is sometimes difficult to find the invoices or shipping bills for the material that is being transported. Moreover, the relevant papers are not always carried on the vehicle; one survey found that 23 percent of trucks carrying hazardous materials failed to carry required shipping papers (Schmidt and Price, 1977). If the papers are found, they are not always understandable to people without an appropriate technical background. Personnel from law enforcement agencies, usually the first responders to transportation accidents, seldom have the knowledge to read technical papers correctly.

Personnel from the transporting carrier are sometimes killed, injured, or disappear from the accident scene, thus precluding questioning by first responders. Of course, such personnel do not always know exactly what type of goods the vehicle had been carrying. There have been cases in which first responders have been unintentionally misinformed by truck or train personnel about the dangerous cargoes that were being carried. Also, it was observed in the study that personnel from the carriers were sometimes reluctant (if not actually uncooperative) to provide relevant information to first responders.

Thus, for all these reasons, first responders are frequently uncertain about the specific nature of the chemical threat even after they suspect that the incident is more than a routine accident. It was rare in the chemical emergencies that resulted from a transportation accident for first responders to learn quickly what they had to face. Also, in some instances, and frequently in accidents that involved multiple dangerous chemicals, responders learned about the hazards long after the incident was over.

Some of the DRC observations on these matters have also been reported by others, especially operational personnel. In a U.S. National Transportation Safety Board hearing, witnesses from the fire service area:

> indicated that reliance on technical manuals, placards, computer printouts, and waybills did not fulfill their informational needs. They stated that all too often placards located on hazardous materials tank cars were destroyed, the knowledge of the train crew was limited as to the exact placement of tank cars and the materials carried, and in immediate emergency conditions, there was not adequate time to search for waybills and cross-reference materials with an emergency manual to determine general emergency actions. (Analysis of Proceedings, 1978: 11)

In accidents that occur in chemical plants in the United States, in contrast to in-transit accidents, there seldom is a problem of identifying the chemical threat, although in one case it took company officials hours after an explosion to realize they had a poisonous gas episode potentially present in the situation. However, there are other kinds of problems that result from the typical behavior of first responders to fixed-site accidents that occur in plants. We observed more than once that company personnel often failed to promptly report to outside authorities fixed-site accidents that involved chemicals. This failure to communicate existed even when the threat expanded or continued to develop outside of the plant grounds. We noticed in our study that community emergency officials often learned by chance about the possible danger to their localities. Not infrequently, the outside community agencies did not find out about a chemical threat until there were obvious sensory cues, such as a toxic cloud.

Given such circumstances, it is understandable that the responders from outside of plants often remain unclear for some time about the specific nature of the chemical threat. They may recognize that the community is possibly endangered and that some chemicals may be involved but have no specific knowledge beyond these impressions. A few situations were observed in which an evacuation was initiated even though the community did not officially know the nature of the danger from which people were being evacuated. In the face of a very unclear and uncertain threat there is likely to be a delay in doing anything, this is the general principle stated in the disaster literature (Quarantelli, 1984b)--that faced with responding or not responding to an uncertain threat, the latter course of action is most likely to be followed.

All efforts by first responders to identify the exact nature of the chemical threat in transportation accidents are beset by a number of difficulties. As previously noted, correct identification of the chemical involved by the first or early responders sometimes does not occur. Incorrect identification may be diffused to many others through rumor among local officials outside of a plant or near the site of a transportation accident. As students of rumor phenomena have stated, the function of rumor behavior is to provide some definition of a situation when none is otherwise readily or officially available (Shibutani, 1966).

Because it is known that a danger exists does not necessarily mean that the exact nature of the danger is understood. Hazardous chemicals may have varied and multiple effects on human beings and on the ecology of the environment. Thus, it was observed in some chemical incidents that even when the identification of the chemical substance was correct, an equivalent recognition of the specific dangerous nature of the threat was not always known. To identify something as a threat does not automatically mean that there is knowledge about the specific nature of the threat or how to handle it.

Our study also found that first responders to transportation accidents tend to overlook two important and dangerous possibilities. In almost all cases there is an initial overlooking of possible synergistic effects, for example, the volatile reaction that will occur if water is combined with calcium carbide. First responders tend to be oriented to the existence of a single chemical agent rather than a multiple chemical agent. In addition, responders to on-site accidents generally do not recognize the different and various kinds of multiple hazards that might be present because of a variety of dangerous chemicals on the same train or truckload. Thus, if a fire is perceived or if one chemical is identified as capable of burning, this is focused on, but explosive, asphyxiating, or corrosive threats that might result from other chemicals involved in the transportation accident are overlooked.

The lack of widespread knowledge about correct stabilization and neutralization procedures is especially significant at the local community level. First responders to chemical incidents often literally do not know what to do, even if they correctly identify the dangerous chemical and know its effects. Thus, even when a chemical threat is correctly identified, fire department personnel (most likely the first responders to the danger) may not act appropriately. Their traditional routine of quickly putting water on a blaze tends to be done automatically; unfortunately, in some instances this can be one of the worst things to do.

Trained personnel also may act inappropriately. In the DRC field work, direct observations were made of trained company emergency response teams who acted incorrectly and endangered themselves and others. Trained teams normally do what should be done; however, it is possible for mistakes in judgment to be made, given the complex nature of dangerous chemicals and the various contingencies involved.

In general, fire departments are not well prepared to respond to most sudden chemical incidents, with the exception of some in large communities and other special cases. They usually lack the appropriate equipment, materials, and protective gear. Moreover, perhaps surprisingly, they often do not know where to turn for information. For example, DRC discovered more than one fire department that had personnel who had never heard of CHEMTREC, the nationwide chemical emergency reporting center. Although the situation has been changing rapidly in recent years, relatively few local personnel have had training in dealing with hazardous chemicals. Many of these weaknesses in coping with chemical incidents result from the primarily volunteer nature of the staffs of the nearly 30,000 fire departments in the United States. Yet it is these volunteer groups that are often among the first responders and that usually are the lead organizations in fighting hazardous chemical threats in transportation accidents.

A major observation of the DRC study was that the initial responding activities of emergency organizations usually follow standard operating procedures. This generally facilitates action being taken by the organizations, but they are not necessarily doing something relevant to the problem at hand. As the nature of the chemical threat becomes clearer, there usually is a tendency to try to adjust to the newly recognized situation. A vast majority of first responders do not have experience from a similar situation that they can rely on. Therefore, experience in responding to any unusual emergency in the past is likely to influence the response to the current situation. We observed in field work during our study that some emergency organizations have relevant technical manuals available; however, they are often inaccessible to the first responders. Moreover, there is considerable variation in the use of such manuals and frequently; as mentioned earlier in this paper, the manuals are not consulted at the height of the emergency.

There is an ad lib quality to the pattern of the first response, especially in transportation accidents. Trying to clarify the situation is often a prime activity. Defining what is happening and what can and should be done is a large part of the early response, but such definitions are not always correct. There is often a delay in defining a transportation accident as one that has the potential to be a chemical disaster. This is in part because there can be many contingencies present in a potential disaster situation. A discussion of the possible contingencies is presented in the next section.

Impact and Situational Contingencies

Different types of contingencies can influence the way in which a community will respond to a particular chemical threat, as well as the degree to which they respond. These contingencies can be divided into two categories:

> Impact variables (or chemical agent variables)
> and situational variables.

However, even though the managing of a chemical incident and its effectiveness will be affected by differences in the chemical agent's impact characteristics as well as by variations in the social aspects of the particular situation, we do not argue for the importance of idiosyncratic factors. In fact, the opposite is stressed in this paper; aspects which appear to be idiosyncratic when observations are made of only one or a few cases, turn out to be more general features or happenings when enough incidents are observed. To a considerable extent, what we shall be discussing as the tactical problems posed by contingencies are what often appear to an unsophisticated disaster planner or operational emergency worker as idiosyncratic or unique in a specific hazardous chemical threat incident.

Impact contingencies.

Impact contingencies include those characteristics of the chemical agent that can affect the organized response. Different chemical agents generate different risks and threats. While risk assessment essentially involves a perceptual component, there are dimensions of risk that are inherent to the chemical agent. For example, some chemicals are toxic, but most are not; a few chemicals can explode, others cannot; certain chemicals only become dangerous when they combine with other chemical substances, other chemicals remain inert.

Thus, the specific characteristics of the chemical agent or agents involved in a major accident will influence the risk and threat to a particular environment. Given the variety of characteristics that might be involved, myriad possibilities of risk could be present. However, many of these variations can be reduced to one of two types of possible consequences: the damaging or destructive potential of the chemical or chemicals, and the ability to control the chemical or chemicals. Both of these characteristics will have implications for the manner in which responders to an incident can and will attempt to neutralize the threat. The situation is complicated, of course, in that responders to the crisis may not correctly perceive either the damaging and destructive potential or the controllability of the chemical threat. Nevertheless, the potential consequences of the risk still remain, even if they are incorrectly perceived.

The damaging destructive potential of any chemical agent is the amount of dage and destruction it can do to people and to the ecological environment. Certain agents have a greater potential for damaging results than others. In general, the high-risk chemicals are those that are extremely volatile or that exhibit an unstable molecular structure. Chemicals that have a high-risk potential are exemplified by the inherent dangers of compressed gases or the hazards posed by gases such as butadiene and vinyl chloride, which are both highly reactive and have a tendency to polymerize. The typical first responder (whether police or fireman) to a chemical accident, unless it occurs within the confines of a chemical plant, usually has little idea of the destructive potential of such substances.

Those managing a chemical threat can be faced with widely differing dangers depending on which chemical or chemicals happen to be involved. Thus, in one emergency the responders might be faced with a relatively low-risk situation. In another emergency the risk may be extremely high. One result is that multiple exposures to chemical risks may not provide a good learning experience that can be used in another emergency situation. Unlike in many natural disasters, experience in one chemical disaster does not necessarily transfer well to the next incident. This great variation in possible damaging destructive potential is an inherent agent contingency in a threatening chemical situation.

There can, however, be more than a threat of impact--there can be actual impact; again there is often substantial variation in the damaging or destructive consequences. DRC studied some actual chemical incidents in which populations that were dozens of miles away from the actual disaster site were endangered. Yet other chemical disasters were examined in which the actual destructive impact was confined to the part of the truck or railroad tank car involved in the accident.

Those managing a localized disaster are presented with different operational and response problems than are the responders to a diffused disaster. Thus, there can be a tremendous difference in threat or impact of a chemical accident, depending partly on inherent qualities of different substances.

In both of the situations previously noted, responders may be presented with different contingencies that are primarily dependent on the inherent properties of the type of chemicals that are involved in the accident. Chemical properties of an agent include flash point, toxicity, vapor density, and synergistic possibilities, all of which can be further affected by meteorological conditions such as precipitation, wind velocity, and other similar factors. This is in addition to the possibility that responders may have incorrectly perceived the chemical danger or even not perceived any threat at all. Perceptual differences aside, however, different dangerous chemicals provide different threat of actual impact contingencies to which those managing the disaster must react.

The magnitude of a disaster can also complicate the response pattern. In a large-scale disaster, the magnitude of which partly depends on inherent properties of the chemical or chemicals, a number of representatives of agencies from different jurisdictional levels will respond to the event. We usually have more involvement of state and federal organizations. This often complicates jurisdictional problems because there are often discrepancies in responsibilities among different governmental sectors. If a disaster is large enough to necessitate a response from state, regional, or federal level of government, or some combination of levels, these representatives will often attempt to exercise authority and control in the situation, sometime over the opposition of local officials. Thus, the contingency of the damaging destructive potential of any chemical agent may influence the coordination of interorganizational response.

In addition to potential or actual destructiveness, there is also the factor of the uncontrollability of chemical agents. Here, too, there may be considerable variation between the inherent uncontrollability of a chemical agent and the responder's perception of this uncontrollability. Our study determined that most community officials are likely to assume that there is a high degree of uncontrollability in most chemical agents. While the same perception exists for most natural disaster agents, the belief is sometimes expressed that this should not be the case for chemical substances. In actuality, a chemical's controllability is only partly dependent on the properties of the chemical agents. Controllability also depends on the amount or volume of the chemicals, as well as on the capability of the community to respond appropriately in the critical period of time immediately following the onset of an accident that has a potential to be a disaster. Usually, the greater the volume, the greater the uncontrollability, everything else being equal. Finally, controllability is partly dependent on the community's ability to perform certain initial response tasks.

While both destructiveness potential and uncontrollability of the agent are inherent to the properties of the chemical, they are not insofar as response is concerned, independent of the perceptual factors. The results of our study suggest that there is misunderstanding with respect to both destructiveness potential and uncontrollability. In general, community officials and the public tend to overestimate the damaging and destructive potential of dangerous chemicals. As in projections of risks at nuclear plants, the threat presumed to exist due to a chemical emergency often exceeds the inherent possibilities of most chemical substances. Chemicals can present major risks and result in major consequences, but they are seldom major threats across-the-board. Most chemicals are not inherently dangerous, but our study showed that the reverse is often the common view; the perception that chemicals are involved in an accident often leads to a perception of danger.

Probably one reason for a general misunderstanding of the potential effects of chemical agents is that, except within the chemical industry, few people have any experience in viewing chemicals and certain risks associated with technological accidents. Although chemical agents are widespread throughout American society, they are relatively random in their manifestations of hazard. That is, the risks posed by dangerous chemicals are not restricted to certain localities or regions of the country. They are nonspecific in this respect. In contrast, most natural disaster agents such as earthquakes, hurricanes, or tornadoes are specific to certain localities. Therefore, it is unlikely that any given population group will have had much, if any, direct experience with dangerous chemicals. Consequently, the image of the risk presented by chemical agents is vague and tends to be exaggerated.

Impact contingencies add to the possible variation and complexity of the response in chemical incidents. In some actual chemical disasters, the situation is further compounded for those managing the event by the multiplicity and variety of hazardous aspects that may be involved. In some acute chemical cases there are often multiple elements of a disaster occurring either concurrently or sequentially. For example, in the derailment of a train carrying dangerous chemicals, the derailment is a problem that must be solved, and there may be resultant fires and explosions due to the derailment. In turn, these may create a chemical spill or toxic cloud that might not otherwise have occurred from the derailment alone.

Situational Contingencies

Situational contingencies include those specific characteristics of the particular social context in which a chemical mishap first occurs. A chemical incident does not just happen. It happens in a particular locality, in a place with distinctive features. A chemical problem also occurs at specific point in time, more accurately, at some social time in the community life. Likewise, there are particular circumstances associated with each chemical emergency; for example, the overturned truck carrying a dangerous chemical cargo may or may not have displayed the required warning placards or signs.

In the following subsections situational contingencies will be discussed that can be classified as variations in location, time or circumstances affecting the response to or the managing of a chemical incident.

Variations in locations.

The location at which a chemical threat or disaster occurs significantly affects the response. A chemical incident, for instance, can occur on private property, a mixed public-private setting, or a public location. These possibilities have implications for a variety of factors, ranging from the degree of knowledge the public will have about the event to the possible courses of action that responding organizations can take. For example, we observed during our research that when chemical accidents occurred inside plants or chemical company property, the larger community seldom found out quickly about such events unless there were immediate casualties. In nearly every case there was a delay between the time that the accident on private property was turning into a potential disaster and when this happening became public knowledge.

There were also situations in which local fire departments were denied entry onto private property on which a chemical emergency was occurring. Situations were studied in which, because the chemical emergency was in a public setting, the response was delayed and confused because no local agency believed it had exclusive responsibility for and jurisdiction over the incident. Such a lack of clarity over response initiative would not occur in a private setting. Thus, the location (actually property responsibility) and whether that property is a private, public, or private-public responsibility (which is a contingency) have an effect on the patterns of managing chemical emergencies.

Another locational contingency involves the geographic and demographic setting of incidents. An obvious possibility that may affect the pattern of response is whether the incident occurs in a rural or urban setting. An accident that might have only minor consequences in a rural area could have potentially catastrophic consequences in an urban area with high population density and heavy concentrations of buildings. The inherent destructiveness of the chemical agent might not differ, but it could vary depending on the geographic setting in which the destructive agent manifests itself.

Each of these events creates different demands, and thus a single situation may involve multiple disaster potentials that generate different demands to which the affected community must respond. Moreover, the incident may generate different emergency related tasks that are incompatible with each other. For example, the water needed to douse the fire might actually trigger a dangerous chemical reaction that otherwise would not occur. This example represents an extreme, but not uncommon, manifestation of the complexities that can be generated for responding organizations by impact contingencies.

Furthermore, we frequently noted in our research that interjurisdictional and interagency problems may arise, depending on the location in which the chemical incident occurs, because many jurisdictional boundaries and domains are often vague. Therefore, if an emergency occurs near the uncertain boundaries of two or more separate jurisdictions, ambiguities can surface about who has the major responsibility for managing the disaster. In particular, chemical disasters that occur in port areas or that involve bodies of water appear to generate jurisdictional problems in the response, although the same difficulties also frequently surface outside of city boundaries. Many rural or quasi-rural areas in the United States are locales where organizational responsibility, authority, and domain are unclear and often overlapping. A chemical incident in such a location is certain to elicit interagency confusion, if not competition or conflict.

Thus, the contingency of the location in which a chemical emergency occurs can have a major impact on the managing of the response.

Variations in time

The time when a chemical threat or disaster occurs also has an important effect on the response. However, it is not chronological time but social time that creates an effect. These two types of times are not equivalent. In every community, there is a rhythm to social life, with certain activities ebbing and increasing in particular patterns and cycles. These patterned activities vary (and not always directly) in relation to the time of day, the day of the week, and the season. Thus, there are community social phenomena such as the rush hour, major sports events, and holiday weekends (Lauer 1981; Zerubavel 1981). Such social times affect where people will be concentrated and what they will be doing, as well as the state of readiness of emergency organizations and how quickly resources can be mobilized.

We noted in our study that there was a significant variation in response, depending on the time at which the incident occurred. For example, evacuation is easier to carry out when it is light than when it is dark. At the Mississauga (Ontario, Canada) chemical incident, massive evacuation was partly delayed, according to police reports, because of a reluctance to try to move a large number of people at night. (See Scanlon and Padgham, 1980.)

Even organizations that operate on a shift basis, and most emergency groups are on a 24-hour basis, do not have either the same quantity or quality of personnel available at all times. Some chemical incidents were studied in which the response developed slowly because higher level emergency officials were not immediately available because the incident occurred outside of regular weekday working hours. In a few cases, certain material resources could not be easily located and used because the organizations owning them were closed and it was difficult to find any personnel with relevant information on how the resources could be obtained or the authority to do so.

Thus, similar to variations in the location of an accident, variations in time can create different contingencies. With respect to time, the rhythms of community life (or social time) can create significantly different situations with which responders must cope. The chemical risks might be identical in two chemical emergencies, but because of the time at which the accidents occur there could be somewhat different situations for the responders and managers to face in the two cases.

Variations in Circumstances

In addition to contingencies due to location and time there are still other possible variations. There may be other circumstances affecting the situation; two of these factors will be illustrated here: the duration of the threat and the speed of onset.

In our research, chemical incidents were observed in which the response activities ranged from a few hours to nearly a week. As indicated earlier in this paper, some events that eventually become chemical emergencies may