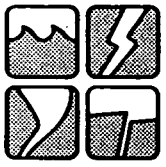

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CHEMICAL EMERGENCIES, OFFSITE EXPOSURES, AND ORGANIZATIONAL RESPONSE

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Introduction

At the present time, the vast majority of the chemical facilities operating in the U.S. are safe and well-managed. Nevertheless, accidental releases that endanger the public continue to occur. Sociologist Charles Perrow (1984) argues convincingly that despite extensive efforts to ensure safety, chemical plants are prone to serious system failures and that accidents are an inevitable by-product of chemical production. Assuming that the hazard cannot be completely eliminated, the alternative is effective management. However, as the discussion that follows will indicate, improving preparedness and response in chemical emergencies, particularly at the local community level, has proved to be difficult.

This paper focuses on the topic of community response to sudden, large-scale releases of hazardous chemicals, rather than on the handling of "chronic" chemical hazards or low-level toxic emissions and with fixed-site accidents, rather than emergencies involving hazardous materials in transport. The paper first reviews the findings of surveys and case studies on chemical emergency preparedness and response. After that, several factors that have impeded attempts to manage these kinds of incidents are discussed.

Scope of the Problem

The U. S. chemical and petroleum industries reportedly manufacture 275 million gallons of gasoline and 2.5 million pounds of pesticides and herbicides every day; an additional 723,000 tons of hazardous wastes are generated daily (Time, 1984). In view of this enormous volume, these industries are remarkably safe. Judging from statistics on accidents in industry, chemical manufacturing and processing plants have a very good safety record. The incidence of occupationally-related deaths, injuries, illnesses and lost workdays in chemical and petroleum manufacturing plants are among the lowest, compared with other industries (National Safety Council, 1984). Nevertheless, chemical facilities still pose potential hazards, not only for workers but also for nearby communities. Despite sophisticated systems designed to mitigate the hazards associated with chemical processing and industry safety campaigns and worker training programs, toxic releases still occur regularly. No emergency of the magnitude of the Bhopal disaster of 1984 or the Mexico City liquified natural gas

explosion of the previous year has occurred here yet, but communities in the U. S. are vulnerable to such incidents. The worst disaster in U. S. history, the 1947 Texas City explosion and fire, involved chemical plants and storage facilities and a freighter carrying nitrates. That disaster, which killed 576 and injured 2,000 persons, is a reminder of the catastrophic potential of hazardous materials accidents.

Chemical emergencies constitute a significant health and safety hazard in many communities, and the precautionary evacuations that are sometimes needed also create considerable social disruption. A partial list of chemical spills compiled by the U.S. Environmental Protection Agency (EPA) for the years 1980-1985 indicates that in that period, 7,000 accidents involving toxic chemicals killed 139 persons and injured 1,478. During that same period, an estimated 217,450 persons were involved in protective evacuations (Chemical and Engineering News, 1985). In the year 1983 alone, the EPA received over 4,600 reports of hazardous materials episodes and provided assistance to state and local governments in 400 incidents (Council on Environmental Quality, 1984). While some of these incidents involved hazardous materials in transit, a significant number occurred in either production or storage facilities. Many plant accidents only affect workers at the site, but those that affect surrounding communities are by no means infrequent. Examples of such incidents include:

---A major explosion and fire involving acrolein in a Union Carbide plant in Taft, Louisiana in December, 1982, which necessitated the evacuation of nearly 20,000 persons (see discussion later in this paper).

---A malathion vapor release from a pesticide plant in Linden, New Jersey in October, 1984, in which thousands of nearby residents were affected and 150 persons were treated after inhaling the fumes (Time, 1984).

---An explosion in a warehouse filled with 24,000 barrels of chemicals in Elizabeth, New Jersey on April 22, 1980, which injured 41 persons, almost triggered a major evacuation, and subsequently polluted a nearby waterway (New York Times, 1980).

While it is not possible to pinpoint exactly the incidence of hazardous materials emergencies nationally (Zimmerman, 1985), it appears that they are increasing in frequency. Communities with

large numbers of chemical facilities seem particularly incident-prone. For example, on June 26, 1985, a fire broke out in a warehouse containing 25 tons of pesticides and fertilizers in the small town of Coachella, California. About 2,000 area residents were evacuated from their homes, and 130 persons were treated for nausea, cramps, and respiratory problems as a result of inhaling the noxious smoke from the fire. The chemicals stored at the facility included parathion and malathion; exposure to high concentrations of these substances can be fatal (Los Angeles Times, 1985b). Only two days before the incident, an estimated 10,000 residents had to be evacuated in an almost identical pesticide warehouse fire in the Anaheim area in nearby Orange County, California. As many as 80 chemicals, including ammonium sulphate, ammonium nitrate, and methyl bromide were involved in the Anaheim episode (Los Angeles Times, 1985a). In one ten-day period in August, 1985, there were three potentially serious incidents involving hazardous chemicals in the greater Charleston, West Virginia area. Two different Union Carbide plants had toxic releases that affected residents of the adjacent communities (the largest of these accidents, which occurred on August 11, is discussed in a later section of this paper).

The problem of community exposure to hazardous chemical emergencies is growing in importance. The volume of potentially dangerous substances that are produced, stored, and shipped has steadily increased in recent years, as has the size of the population exposed to the hazard. Most chemical plants are located in large metropolitan areas rather than in remote, sparsely populated communities; the five communities with the largest number of chemical plants in the U. S. are also the five largest metropolitan areas: New York, Los Angeles, Chicago, Philadelphia, and the San Francisco-Oakland-San Jose metropolitan area (Library of Congress, 1985). Even communities that do not have chemical plants are increasingly vulnerable to transportation accidents, which in general are even harder to manage than fixed-site emergencies.

The potential for a major emergency involving hazardous chemicals exists in a number of communities. Despite the fact that the safety record of the industry is very good, there are substantial risks associated with chemical production and storage, and the growing concern about offsite exposures is quite justified.

Studies of Chemical Emergency Preparedness and Response

Disaster Research Center/National Science Foundation Study

The literature on chemical hazards focuses overwhelmingly on the prevention and control of in-plant accidents and on various aspects of worker safety. Only in the last ten years have a few studies appeared that focus on preparedness and response in communities adjacent to chemical facilities. While the literature on chemical safety was mainly developed by engineers and specialists in industrial hygiene, studies of the broader community impact have been undertaken by primarily by social scientists interested in community and interorganizational co-ordination and in emergency management problems.

The largest single study of hazardous materials emergencies was conducted by the Disaster Research Center, then at Ohio State University, between 1977 and 1981. The purpose of the study, which was funded by the National Science Foundation, was to explore social factors that affect awareness of, preparedness for, and response to chemical hazards. The primary units of analysis were local communities (cities and counties), and the scope of the study was national.

The first phase of the research focused on hazard awareness and emergency preparedness. In this stage, field studies were conducted in 19 small, medium, and large communities throughout the U. S. that, based on available data on chemical production, storage, and transportation appeared to have a higher-than-average risk of a major chemical accident. These communities are listed below in Table 1.

Table 1: Communities in DRC Study of Emergency Preparedness

Akron, Ohio	Houston, Texas
Baton Route, Louisiana	Kingsport, Tennessee
Big Spring, Texas	Linden, New Jersey
Buffalo, New York	Los Angeles, California
Charleston, West Va.	Louisville, Kentucky
Chattanooga, Tennessee	Memphis, Tennessee
Cincinnati, Ohio	Midland, Michigan
Findlay, Ohio	Mobile, Alabama
Galveston, Texas	Niagara Falls, New York
	Savannah, Georgia

In each community, interviews were conducted with key individuals in chemical facilities and community emergency preparedness and response organizations. Typically, the organizations contacted for interviews would include: chemical manufacturers and transporters; the local civil defense office; the local chapter of the American Red Cross; the police department; the local or regional environmental protection organization; the major general hospital; city and county fire departments; the county sheriff's department; city and county governments; the U. S. Weather Service; industrial mutual aid organizations; and other crisis-relevant groups and organizations. The interviews contained questions on respondents' perceptions of the magnitude of chemical hazards and on various aspects of local chemical emergency preparedness.

In this phase of the study, the DRC researchers noted some significant patterns. First, awareness of chemical hazards in the community was relatively high among all the organizations contacted in all 19 communities. Among approximately 300 respondents who were asked to rate the probability of occurrence of 36 different natural and technological disaster agents, three types of chemical emergencies (chemical spill, major plant explosion, and toxic substance release) were judged to be among the five most probable emergency events. However, not all respondents saw such emergencies as equally probable. Chemical producers and transporters viewed chemical emergencies as less likely than did interviewees who worked in in public agencies. In general, respondents in large and medium-sized communities were more likely to see chemical disasters as a problem than those in small towns (Helms, 1981).

The research also revealed major gaps in preparedness for hazardous materials emergencies. In the communities studied there was no single organization acknowledged as having responsibility for overall risk assessment for chemical hazards. Moreover, with the exception of the industry-sponsored mutual aid groups, no local organizations were attempting to foster improved interorganizational co-ordination for chemical emergencies. Local fire departments were more likely than any other public organizations to have had contact with chemical manufacturers and to have engaged in preparedness activities (such as conducting disaster drills and developing written guidelines) for toxic releases.

However, fire department knowledge and expertise tended to not be reflected in community-wide (as opposed to organizational) emergency plans. Chemical companies appeared to be well prepared for in-plant accidents, but their emergency plans were not linked to the disaster plans of the community organizations such as civil defense offices that are responsible for protecting the public in emergencies. About one-half the communities studied had chemical industry mutual aid bodies that engaged in disaster planning, but for the most part their activities were again not linked to community-wide disaster planning efforts. Members of mutual aid organizations focused their efforts mainly on preparing to help one another control in-plant incidents, not on other emergency management tasks such as hazard assessment, prevention of accidents, or community-wide response planning (see Tierney, 1980 and Quarantelli, 1984 for more information on findings from this phase of the study).

In the second phase of the research, conducted mainly in 1979 and 1980, DRC studied emergency operations in 20 separate hazardous materials incidents in eight different states. The incidents, which involved both fixed-site and transportation emergencies, ranged from relatively localized events to major community emergencies such as the 1979 Mississauga, Canada train derailment. The communities in which the incidents occurred included large metropolitan areas, small towns, and rural areas. Data were obtained by means of interviews with key actors in the various incidents; analysis of emergency plans, after-action reports, newspaper stories, and other documentary materials; and, in several cases, direct observation of emergency response activities. The major objectives in this phase of the research were to: (1) reconstruct each incident, with special emphasis on the performance of key emergency tasks such as identification of the hazardous substance by first responders, notification of emergency officials and the public, and evacuation; (2) assess the degree and quality of interorganizational co-ordination and identify problems that typically arose in these incidents; (3) develop hypotheses about factors that might account for the emergency response patterns that were observed; and (4) determine whether these kinds of incidents differ from natural disasters in the way they are managed.

In general, the researchers found that reponses to emergencies involving hazardous materials

did differ somewhat from those involving natural disaster agents. Because chemical disasters are not well understood by the majority of local disaster-relevant organizations, there was initially a lot more uncertainty about how to respond. Fire departments were usually the focal responding organizations in chemical emergencies. Since the fire department is frequently not the main community disaster planning agency or the co-ordinating organization in other emergencies, it was not unusual for confusion to develop about which organization actually had overall authority for management of the incident. Chemical emergencies tended to be accompanied by more interorganizational conflict and to be less well-handled than natural disasters.

DRC researchers found that emergencies involving hazardous materials in transport were more problematic for responding agencies than those occurring in fixed facilities, but the differences were mainly in degree, rather than in kind. It usually took time for first responders to identify what chemical or chemicals were involved and even more time to pass this information on to relevant responding organizations. In chemical companies, it was somewhat easier to identify what substances were involved in an accident, but company personnel still tended to be slow in providing information to public emergency response agencies, even when the release presented an obvious threat to the surrounding community. Rather than learning about the accident from sources at the site, emergency organization personnel might first hear about it from members of the public calling to inquire about an unusual odor or explosion. Initial decisions, such as the decision to call for additional outside resources, were often made by these officials without a clear understanding of the nature of the chemical hazard (Gray, 1981). In a few situations, evacuations were ordered by local personnel even they they did not actually know what chemicals were involved in the release (Quarantelli, 1984).

Numerous extra-community organizations and resources (state, regional, and federal agencies, outside ambulance companies and emergency crews, etc.) tended to converge during major incidents. This was one factor that made communication and co-ordination among responding organizations more difficult. Moreover, emergency operations centers, which are typically activated in natural disasters to bring together persons with decision-making responsibility in different emergency task areas, were usually not set up in chemical emergencies. Instead, command posts staffed by public

safety personnel (usually, fire and police departments) were set up close to the scene. Because overall co-ordination among all relevant community and extra-community responders could not be achieved during these incidents, information gaps developed, and some emergency tasks were not carried out effectively. For example, while the responders on the scene may have known details of the incident, such as how many persons were in need of medical assistance or what chemicals were involved, this information tended to not be relayed to other off-site organizations that needed it, such as hospitals. The study also found that this lack of overall co-ordination meant that members of the mass media and the general public were also not informed of the nature of the threat and appropriate actions to take. On this topic, Quarantelli (1984: 104) notes:

> ...since the primary source of information in a chemical emergency is likely to be an inadequate one, incomplete, conflicting, and often erroneous information about the emergency will circulate. This is especially dysfunctional because in a prolonged emergency even the organized responders become partially dependent on mass media accounts for information about the incident...the lack of complete and accurate information about the chemical threat becomes a problem for community residents who need to have some knowledge about the nature and duration of the threat...

In those incidents that were long in duration, better interorganizational communication and co-ordination tended to develop over time (Gray, 1981).

As noted earlier, various forms of interorganizational conflict were also frequent in these episodes. For example, disputes over jurisdictional responsibility and authority were common, particularly in large-scale events in which different governmental levels were involved. Relations between public emergency response agencies and chemical companies were frequently characterized by mistrust and conflict.

The DRC researchers concluded that pre-disaster preparedness efforts had a positive influence on the quality of the emergency response. However, they also noted that various contingencies, which they termed impact and situational factors, affect the community's ability to respond to the emergency. Impact contingencies include the degree of hazard associated with the released chemical(s) and the extent to which the toxic agents can be contained or controlled. Situational contingencies include the location of the incident, the time of day the release occurs, and how quickly the hazardous situation develops. These kinds of factors can mean the difference between a

well-managed and a poorly-managed emergency response (Quarantelli, 1984).

That research was conducted nearly ten years ago. Since the early 1980's, in part as a result of the 1979 Three Mile Island nuclear accident and the 1984 Bhopal tragedy, government, industry, and the general public have become much more aware of and concerned with technological hazards. Nonetheless, there is evidence that the same problems that the earlier research identified still occur, as the research findings discussed in the next section indicate.

Other Studies of Chemical Emergency Preparedness and Response

St. Charles Parish, La. In January, 1983, the Disaster Research Center conducted a study of a December, 1982 chemical plant emergency in Taft, Louisiana, near New Orleans, under contract with the Federal Emergency Management Agency. The emergency involved an overheated tank of acrolein that exploded just before 1:00 am the morning of Saturday, December 11, causing a damaging fire and hazardous fumes that resulted in the evacuation of approximately 17,000 community residents for about 36 hours. The objective of the study was to describe the activities of local emergency organizations with respect to the evacuation that took place, which was initially believed to have been influenced by nuclear plant evacuation planning.

St. Charles Parish, where Taft is located, has a high concentration of chemical and petrochemical facilities and is also vulnerable to natural disasters such as hurricanes and floods. Planning for natural, industrial, and nuclear emergencies was extensive. The parish was considered well-prepared for all types of disasters.

Although the emergency response in this episode was considered quite adequate by the participants, several problems were identified. First, the company did not notify the local sheriff's department that there was a problem at the plant until more than an hour after it had begun evacuating workers. Despite the potential hazard to the community and the growing concern of residents who knew the plant was being evacuated, the emergency was treated as routine within the plant. Second, local public safety officials were not able to obtain information on the severity of the hazard to the community for three and one-half hours after the explosion. At that point an evacuation of the population within a five-mile radius of the plant was ordered on the

recommendation of company officials. Third, chemical industry and public-sector emergency responders maintained separate emergency operations centers throughout much of the incident, which restricted the flow of communication between the public and private sectors (Quarantelli, Hutchinson, and Phillips, 1983).

Kanawha County, West Va. Following the December, 1984 Bhopal disaster, public attention was focused on greater Charleston and Kanawha County, West Virginia, where Union Carbide manufactures methyl isocyanate at its plant in the small town of Institute. Despite efforts to improve both in-plant safety at the Institute facility and community emergency response capability, there was a toxic leak at that plant in August, 1985 that injured approximately 135 community residents and resulted in an evacuation of the area around the plant. I conducted a small-scale field study in Kanawha County one week after the event to obtain information on the emergency response and assess the adequacy of post-Bhopal efforts to address chemical hazards in the area. The sections that follow summarize what I found on that trip.

Kanawha County has about 900 square miles of area and a population of approximately 231,400. Charleston, West Virginia's largest city and capitol, is the county seat. Charleston and most of the other incorporated towns in the county are located on the Kanawha River; much of the county is mountainous, and the population is concentrated along the narrow river valley. Rather than being isolated, chemical facilities are located very close to populated areas and major transportation routes. The Union Carbide plant at Institute is an example. It is very close to a residential area; directly across the plant fence, within one hundred yards, the state operates a vocational rehabilitation training center and medical facility that serves three hundred seriously disabled patients.

The chemical industry is extremely important to the local economy. Approximately 30 chemical plants of varying sizes are located along the river, and virtually every major chemical company has one or more facilities there. Chemical production is by far the largest industry in the manufacturing sector; in the early 1980's the chemical industry accounted for more than 10,000 of the 15,000 manufacturing jobs in the county and 12,300 of the 19,000 manufacturing jobs in the Charleston SMSA. Hazardous chemicals are transported through the county by truck, rail, and river barge.

The Kanawha Valley differs from many U.S. communities in that awareness of chemical hazards is high among residents and public officials. Charleston and the smaller surrounding communities have had extensive experience with hazardous materials releases, and almost everyone has a family member who worked in the local plants. Despite this awareness and despite the high level of risk, public sector chemical emergency preparedness in the area was no more advanced or sophisticated than in most other communities. Before Bhopal, preparing for hazardous materials releases was not a priority for local governments in the area. The situation with respect to chemical hazards might best be characterized as a combination of benign neglect and reliance on industry paternalism. The county office of emergency services, with a small staff and a very low budget, developed standard disaster plans in compliance with federal guidelines; their emphasis was on nuclear attack and natural hazards. The main organization involved in planning for toxic releases in chemical plants was an industry group, the Kanawha Valley Industrial Emergency Planning Council (KVIEPC), which was originally formed and still dominated by local chemical companies. Government, public safety, and emergency medical service organizations were represented on this planning council, but community-wide disaster preparedness was not its main goal; instead, the focus was on providing assistance for in-plant emergencies. The communities in the Valley relied on local industry to provide timely information (e.g., evacuation advisories) in the event of an actual or threatened release.

Following Bhopal, public officials at all governmental levels began to acknowledge that local industry and the community needed to do more to plan for a large-scale emergency involving highly hazardous materials. Interest started to focus on improving public education with respect to evacuation and on making evacuation plans more consistent across organizations and jurisdictions. Beginning in February, 1985, a series of community meetings were conducted by government, public safety, and industry representatives in towns throughout the Valley to inform residents about evacuation warnings, procedures, and routes. Documents detailing emergency evacuation procedures were also mailed to all residents. The documents distributed in the majority of communities were identical in format and wording, except for the attached street maps, which were specific to different geographic areas. The evacuation plans were based largely on traffic diversion procedures that had

been developed a number of years earlier by KVIEPC. (That organization dropped the word "Industrial" from its name in January, 1985 in an attempt to show that it was shifting its emphasis from industry to a broader community focus.) In the course of developing these new procedures, it was discovered that older plans were not consistent with one another and, in some cases, with the law.

Like earlier planning documents in the community and most local emergency preparedness measures, the new procedures still relied on the chemical plants to voluntarily provide information on sudden toxic releases. The plans stipulated that, upon notification by plant officials that a serious accident had occurred, local volunteer fire departments would sound sirens, indicating to residents that they should tune to their radios for further instructions. The decision on whether or not to order an evacuation was the responsibility of the local volunteer fire department.

While undoubtedly well-intentioned, the planning process had major shortcomings. As new evacuation measures were being considered, little attention appears to have been paid to studies of factors that affect public warning response and evacuation behavior (for summaries, see Perry and Mushkatel, 1984; Drabek, 1986). Some residents, particularly those in Institute, were initially skeptical about whether evacuations could really be conducted in a timely, orderly manner, given the terrain and the carrying capacity of local roads. Many of the community meetings held to inform the public were not well-attended. (One person I interviewed described a meeting where a committee of eight officials and industry representatives assembled to present the evacuation plan to an audience of three.) The evacuation guidelines were not developed and disseminated in ways that would lead them to be understood and taken seriously by members of the community. Some residents complained after the August release that the few evacuation simulations that were held to try out the plan took place during the day, when most adults were at work.

Other strategies besides evacuation planning could have been emphasized in the greater Charleston area following Bhopal. For example, legislation could have been introduced mandating comprehensive chemical emergency preparedness, or companies could have been required to increase worker safety training programs or reduce inventories of highly hazardous materials. Union Carbide

did invest approximately $5 million in an improved safety system for its MIC plant at Institute, and a statewide community right-to-know law was passed in 1985. However, so far as I was able to determine no other significant efforts were made in Kanawha County to mitigate chemical hazards, mobilize additional emergency resources, or alter organizational procedures.

When the release of aldicarb oxime and other chemicals occurred early on the morning of Sunday, August 11, the emergency response did not proceed as planned. There was a delay in notifying community officials and residents about the incident. The warning siren was not activated until 9:45 am., when it was already obvious to many residents that a major accident had occurred. According to a survey of 207 Institute households conducted by the office of Congressman Bob Wise the next day, more than half of the residents interviewed reported learning of the release by smelling the escaped gas; only 16% of the respondents indicated that they learned about the release by hearing the emergency siren. Fifty-five percent of those interviewed were already aware of the accident by the time the alarm sounded. Ninety-two percent of the respondents did not consider the warning procedure adequate. A number of people didn't hear the warning siren at all, and some heard it but didn't understand its significance (Wise, 1985). The state rehabilitation facility that is directly adjacent to the Union Carbide plant had a special telephone link with the plant that was supposed to be used for early emergency notification, but the facility was not notified until 10:00 am., fifteen minutes after the community alarm sounded.

Union Carbide's prestige, which was already low, was further damaged by the Institute accident and another release that occurred at its South Charleston facility two days later. Following those incidents, many community residents continued to express positive views about the company and the chemical industry, but others were outspokenly critical. Approximately 300 persons attended a public meeting in Institute one week after the August 11 release to express their outrage demand improved safety measures. Both local residents and some public officials began stating that the corporation's post-Bhopal activities in the Valley were motivated more by public relations considerations than concern with safety. Negative mass media reports generated by the Bhopal catastrophe had begun to decline, but the Institute accident brought renewed criticism of Carbide's overall management and

its approach to safety (see, for example, Los Angeles Times, 1985c). A major lawsuit charging company negligence was filed by some victims of the August 11 release. That accident also prompted the Occupational Safety and Health Administration (OSHA) to do a wall-to-wall inspection of the Institute facility. Numerous safety violations were found, and the company was later fined $1.4 million.

General Accounting Office Study. In 1985 and 1986, because of Congressional concern following the Bhopal incident, the General Accounting Office (GAO) reviewed state, local, and industry programs to determine what measures were in effect to improve local community preparedness for accidental airborne releases from chemical facilities. Data were obtained from various federal agencies, the governments of three states (Louisiana, Michigan, and New Jersey) and six counties that have large numbers of chemical manufacturing facilities, the Chemical Manufacturers Association, the American Institute of Chemical Engineers, and eight chemical plants. While the GAO avoided making explicit evaluative statements, the study findings, released last year (General Accounting Office, 1986), suggest that efforts to improve emergency planning and response vary in quality and comprehensiveness.

The report begins by noting that there is no federal legislation requiring communities to plan for hazardous materials emergencies. However, Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, in requiring a National Contingency plan for hazardous spills, provides a basis for federal interagency co-ordination. The report outlines activities of various federal agencies that have emergency response preparedness and responsibilities, including the Environmental Protection Agency and the Federal Emergency Management Agency.

At the state level, the GAO reports that at the time of its study all three states had formal plans for emergencies, but only one state plan (Louisiana's) specifically addressed chemical plant releases. Each of the states had also passed community right-to-know laws that were just starting to be implemented. Louisiana and Michigan had state-level programs to train local emergency response personnel for chemical incidents; training is a county responsibility in New Jersey. The three states

all had laws requiring releasers of hazardous materials to notify the appropriate state authorities, but these laws were reportedly not well-enforced. Of six counties visited in the GAO study, three had emergency response plans that specifically addressed chemical emergencies and three had general plans applicable to various types of emergencies.

The GAO obtained information from the Chemical Manufacturer's Association, the main chemical industry trade organization, on its community preparedness and emergency response programs. These include the Chemical Transportation Emergency Center (CHEMTREC), instituted in 1971; CHEMNET, a mutual assistance network; various training programs for hazardous materials handlers and first responders; and the Community Awareness and Emergency Response (CAER) program, established in 1985 to improve co-ordination between chemical facilities and local emergency organizations. CMA officials reported that by January, 1986, 174 companies and 1,200 chemical plants were participating in the CAER program.

Representatives of the GAO visited eight chemical plants in the three states in 1986 to learn about their emergency planning. The plants ranged in size from 30 to 1,300 employees. Five of the eight plants reported being involved in the CAER program at the time they were studied. All eight had emergency response plans. Three of the facilities reported having disaster drills that involved one or more local public safety agencies (mainly fire departments) once a year; one organization reported conducting two drills per year with the local fire department. Three companies conducted in-house drills; in two cases, these drills were held twice a year. One company reported that it had not held any emergency exercises. The largest company in the group was among those that conducted only in-house response simulations.

The GAO report concluded that several promising initiatives had begun as a result of the concern generated by the Bhopal accident, including EPA's Chemical Emergency Preparedness Program and federal interagency co-ordination efforts, but that it is too early to determine how effective they will be in improving the ability to respond at the local level.

Recent evidence suggests that while public awareness and organized efforts to manage the hazards associated with toxic chemicals have both increased, relatively little tangible progress has been

made. The next section of the paper discusses factors that may impede such progress.

Factors that Affect the Management of Chemical Emergencies

A number of factors combine to complicate attempts to better prepare communities for chemical disasters. These factors relate to culture, social organization, and societal and community resources.[1] While some of the same constraints apply in the area of natural hazards, the situation with regard to chemical emergencies has several distinctive elements.

Cultural Influences

Compared with natural disasters, chemicals and other technological disaster agents are not well understood by either the general public or most emergency responders. Some technological hazards are greatly feared by the public (Slovic, Fischhoff, and Lichtenstein, 1979). The way hazardous chemicals and other technological agents are perceived tends to complicate debates on management strategies and the response to actual incidents. For example, Perry and Mushkatel (1984) suggest that when hazardous materials accidents occur community residents have a tendency to turn more to official sources than to members of their social networks for guidance, because public officials are seen (sometimes incorrectly) as having the necessary expertise--which can result in demands for information that exceed government capability. Kasperson and Pijawka (1985) discuss other ways in which the perception of technological hazards is likely to affect the public's response and long-term outcomes.

Another distinctive feature is that attempts to address these hazards seem inevitably to involve ideological conflicts. One obvious reason this is the case is that technological hazard management involves private businesses. The conservative belief is quite strong that private enterprise should be interfered with as little as possible, and industry typically finds support for its efforts to resist mandatory controls. Private organizations in this society greatly value their autonomy. Efforts to regulate industrial health and safety were accompanied by more ideological conflict in the U.S. than in other societies such as Great Britain (Wilson, 1985). Among those persons interviewed in the DRC study of chemical emergencies, Quarantelli (1984:61) reports that

> there was an implicit and sometimes explicit idea expressed in many communities...that the public sector must not intervene too strongly in private sector activities, even in matters of safety. This attitude appears to be particularly prevalent when chemical producers and/or transporters employ a significant portion of the labor force...

Americans also believe that policies should not be adopted that make some companies less able than others to compete. Until recently, for example, chemical companies could successfully argue on these grounds for their right to privacy about what was being produced at particular sites, even though such information could have led to better emergency preparedness.

Social Organizational Factors

As Carnes (1986) notes with respect to the transportation of hazardous materials, the institutional context for chemical industry emergency management characterized by complexity and rapid change. At present, more effective handling of chemical emergencies involving community residents is impeded by the fact that overall responsibility for such incidents is still very unclear (Zimmerman, 1985). There is no federal legislation that mandates preparedness planning for chemical emergencies and no counterpart to the Federal Emergency Management Agency (FEMA) in the chemical hazards area. FEMA has no statutory authority for planning and response for chemical disasters, although it has produced emergency planning guidelines (Federal Emergency Management Agency, 1981) and assisted in the relocation of seriously contaminated communities. Existing federal regulations were not intended to mitigate, prepare for, or respond to sudden, large-scale emergencies at chemical facilities. Discussing the Environmental Protection Agency's inspection of the MIC unit in the Union Carbide plant in Institute, Chern (1985:22) notes that

> ...EPA officials realized that the compliance review did not really address the issue of overall plant safety. In fact, the inspection clearly revealed that existing environmental laws and regulations were not principally designed to prevent catastrophic accidents but rather to limit routine and expected pollutant discharges.

EPA's new Chemical Emergency Preparedness Program is an effort to assist communities in developing chemical emergency management plans. However, the program is voluntary and has limited resources.

State governments have attempted to remedy the lack of specific authority for chemical emergency preparedness through legislation. Many states have passed community "right to know"

laws. In 1985 and 1986, California enacted strong legislation making the disclosure of hazardous materials inventories to local administrative agencies mandatory for handlers and requiring businesses to prepare emergency plans that are consistent with those of public-sector emergency management organizations. In early 1986, New Jersey also passed a law requiring manufacturers of highly hazardous chemicals to engage in emergency planning and training efforts. (These laws were passed in the aftermath of Bhopal and may not have been politically feasible had that disaster not occurred.) While such laws indicate potential progress in addressing problems of community preparedness, it is too soon to determine how they will be implemented and what their eventual outcomes will be.

Another factor that affects chemical emergency management at the community level is that planning for and responding to chemical incidents seems to be inherently more organizationally complex than natural hazard management. These types of incidents not only involve public and private sector co-ordination at the local level but also also require the establishment of vertical linkages--contacts with various supra-community entities such as regional response teams, corporate headquarters, state environmental and health agencies, providers of specialized resources, and other outside groups. (Natural disasters also necessitate vertical linkages of various kinds, but these relationships are more routinized and have a better basis in existing legislation and plans than those in the chemical hazards area.) Having to take these organizational complexities into account complicates both planning and response. Maintaining extensive interorganizational linkages is costly, and few incentives are provided to either public or private organizations for doing so.

Measures to improve the management of chemical accidents can be designed at the federal and state levels, but emergencies involve local jurisdictions, and local organizations are inevitably involved in the first response. The fact that wide chemical emergency management at the local level must necessarily build upon a relatively weak organizational foundation is another constraint. Disaster preparedness and response are generally not considered politically glamorous issues in this society; compared with other issues on the political agenda, public officials do not view hazards as a priority (Rossi, et al., 1982). While the situation is changing as the field of emergency services becomes more professionalized (Petak, 1984), local emergency management agencies in many communities still

tend to be low in organizational prestige, under-funded, understaffed, and far removed from the center of political decision-making (Quarantelli and Tierney, 1979). Drabek (1986) argues that the effectiveness of local emergency management agencies is associated with their centrality in emergency interorganizational networks; some agencies are not particularly effective with respect to natural disaster planning. Given their relative lack of resources and personnel, many offices of emergency services currently may not be capable of assuming an effective leadership role in the hazardous materials area, even if mandated to do so. In other words, emergency management organizations charged with the responsibility for bringing about better industry-government co-operation are not starting from a position of strength (see discussion of resources below for other evidence).

Resource Issues

The term resources refers to personnel, information, facilities, equipment, and funds that could be used to respond to the problem of accidental chemical releases. There are two general sets of resource problems in this area: resource shortages and gaps, and problems with resource mobilization.

Currently, there are not sufficient resources to enable public agencies to effectively manage hazardous materials emergencies. As noted above, many communities lack the ability to respond well to incidents when they occur; however resource gaps are even more evident with respect to other key management phases, such as hazard identification, risk analysis, and hazard mitigation. For example, government agencies charged with monitoring chemical industry safety are not able to perform comprehensive assessments of even a small fraction of the nation's chemical plants. OSHA's Special Emphasis Program, launched to enable the agency to look into safety procedures at plants producing the most dangerous chemicals, turned out to be even more time consuming and labor-intensive than expected (Hanson, 1986); at the pace and on the scale the program was conducted, it is unlikely to have an appreciable national impact on safety.

One of the most basic management problems cities and counties have is that they lack information about what their local chemical companies are producing and how much of a hazard those chemicals pose to the community. Programs to inventory and evaluate hazardous chemicals require a data-collection strategy, record-keeping systems, and personnel who understand the hazard--

all of which can be expensive. By developing and disseminating a list of substances judged by experts to be highly hazardous, the Environmental Protection Agency has at least begun to help communities address one aspect of this problem.

I noted earlier that the organizations that have overall responsibility for emergency management may not now be in the best position to assume a leadership role in the chemical hazards area. This is in large part a result of insufficient resources. Since approximately 1980, local emergency management agencies have been charged with developing "integrated emergency management" approaches that take all hazards into account--including technological hazards, which have recently grown tremendously in their magnitude and importance. They have also been asked to focus on all stages of hazard reduction (including mitigation and recovery) not just on planning and emergency response. This expansion of the emergency management role has not been accompanied by a concomitant increase in funds and staff, and the shortage of resources is particularly apparent in the hazardous chemicals area, which is relatively unfamiliar to most emergency managers.

Although there are areas where more more resources are clearly insufficient for responding to these kinds of emergencies, the more common problem is the inability to link and mobilize existing resources. In other words, many resource problems are really organizational problems. For example, all communities that have chemical plants and fire departments have "resident experts" who know a considerable amount about chemical hazards. Members of these organizations could be taking part in training and public education programs for other organizations and for community residents--but often this does not occur. The Chemical Manufacturers Association's CHEMTREC hotline is another valuable resource for local emergency responders. The Disaster Research Center study of community preparedness found that while most fire department personnel interviewed were familiar with CHEMTREC, officials in other emergency-relevant organizations did not (Quarantelli, 1984); this is, again, not so much a problem of resources as of organization. Chemical companies and mutual aid groups typically have access to specialized resources, but their plans may not be linked with those of the public sector.

The Chemical Manufacturers Association's CAER program was initiated in 1986 specifically to urge

chemical companies to provide information and establish linkages that would lead to more effective overall management of chemical emergencies (see Chemical Manufacturers Association, 1986 for an outline of the strategy). It developed out of a recognition that public concern about chemical hazards is increasing and that more co-operation between government and the chemical industry is needed to respond to the problem. Like several other new laws and programs discussed in this paper, CAER has not been in existence long enough to have had an impact, but it warrants future study.

Conclusions

During this decade, public awareness of the severity of the hazardous materials problem has greatly increased. Along with this growth in awareness has come an increased demand that government and the private sector do more to protect the health and safety of community residents following accidental releases. Studies of chemical plant incidents that have affected community residents indicate recurring problems with overall emergency management and interorganizational co-operation; preparedness efforts are also fragmented and lacking in overall direction. Key organizational actors in both the public and private sector are aware of many barriers to more effective handling of chemical incidents, but the problems still continue.

Since the 1984 Bhopal disaster, new legislation and programs have been developed in an attempt to reduce the hazards associated with toxic substance releases. All these interventions are, in a sense, natural experiments in social change, and they warrant close study. In fact, this entire area is one in which more research at both policy and operational levels is needed, because not enough information is available on the likely outcomes of different hazard management strategies. The following are among the questions that deserve detailed study:

(1) What impact have recently instituted mandatory programs had on emergency preparedness and response?

(2) What factors make for exemplary chemical disaster preparedness at the local level?

(3) What factors impede or facilitate progress in the mitigation of the risks associated with chemical production?

(4) What impact have recent federal and industry initiatives had on chemical emergency preparedness and response?

(5) How are citizen right-to-know laws being implemented in U.S. communities, and what effect, if any, are they having on community preparedness for disasters?

As concern with the problem of chemical emergencies has deepened, a number of new hazard management strategies (new legislation, increased regulation, elimination of some hazards, increased public involvement in toxic chemical issues, and other approaches) are being proposed. Research is needed to gain more insight into which existing and proposed strategies are most likely to work.

Note

[1] Disaster Research Center publications (Tierney, 1980; Quarantelli, 1984) present an "open-system" model that was developed to to explain the social and organizational response to chemical hazards. That model contained three factors that are similar to those discussed here: (1) social climate, or the norms, values, and beliefs that influence behavior; (2) social linkages, or relations among organizations with emergency-relevant tasks; and (3) various types of resources.

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