Journal of Hazardous Materials, 27 (1991) 3-26
Elsevier Science Publishers B.V., Amsterdam

Adoption of emergency planning practices for chemical hazards in the United States

George O. Rogers* and John H. Sorensen

*Hazard Management Group, Energy Division, Oak Ridge National Laboratory***, Oak Ridge, TN 37831 (USA)

Abstract

Emergency preparedness for chemical hazards is a relatively recent phenomenon. The earliest plans were adopted in the late 1960's but more than half of the existing chemical plans were enacted after 1987. The central purpose of this paper is to examine factors underlying variations in levels of community preparedness for chemical hazards. Ideally, the implementation process would be observed directly in a number of communities to determine the events and factors that stimulate the adoption of various planning practices; However, such a study is probably unrealistic, expensive and unlikely to be able to observe enough of the process to be useful. This paper examines survey data collected in late-1987 and mid-1988, in support of the SARA Title III Section 305b Report to Congress. Five factors related to the adoption of state-of-the-art planning practices among local community emergency management organizations are examined: innovation, available resources, necessity, vicarious experience, and professionalism. While each of these factors exhibit relationships with the adoption of state-of-the-art planning practices, none is sufficient to explain the trends in the adoption of planning practices. Supporting evidence is presented that links the adoption of state-of-the-art planning practices to the evaluation of risk in the community and innovation in other related areas.

Introduction

While local governments have been doing emergency planning for a number of years, concern about preparedness for chemical hazards is a relatively recent phenomenon. As in other diffusion and adoption processes, some emergency planning offices have been innovators adopting planning practices early, while others have taken longer. Among those adopting planning practices, the level of planning and sophistication of planning practices ranges from the community with a page-long annex in their general emergency plan to communities with detailed procedures and computerized decision support aids.

*To whom correspondence should be addressed at Hazard Reduction and Recovery Center, College of Architecture, Texas A & M University, College Station, TX 77843-3137.
**Operated by Martin Marietta Energy Systems, Inc. for the U.S. Department of Energy under Subcontract No. DE-AC05-84OR21400 with the U.S. Department of Energy.

0304-3894/91/$03.50

The adoption of state-of-the-art emergency planning practices appears to be occurring for the same reasons that other planning practices are adopted: more sophisticated emergency managers, the development of a considerable body of technical support for planners, and accumulated experience with emergencies. This paper examines factors leading to the adoption of emergency planning practices for chemical hazards among local government emergency organizations.

Hazard experience and adoption of emergency plans

The frequency of chemical accidents reported by AP/UPI involving public response by year and type of accident is presented in Fig. 1. Sorensen [1] examined the frequency of chemical accidents resulting in an evacuation of the public in the five year period, 1980 to 1984. He found more than 50 chemical accidents a year, on average, involved the evacuation of at least 10 people. The frequency of chemical accidents reported by AP/UPI has nearly doubled since 1984, involving over a hundred accidents a year (on average). The most obvious explanations are that the media reporting increased or the number of evacuations increased. Without data on the frequency of accidents that were not reported by the media it is impossible to determine the causes of the increase in 1985. Recalling that the accident in Bhopal occurred in December 1984 suggests that reporting practices may be related to the increased frequency of reports. Whether due to an actual increase in events or the greater scrutiny by the media, the experience of the 1980's suggest that conditions existed for the increased adoption of emergency plans for chemical hazards.

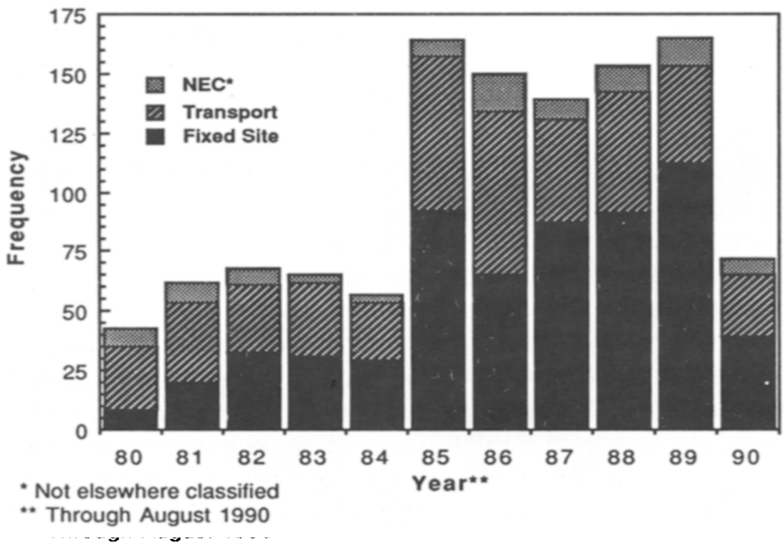

Fig. 1. Frequency of chemical accidents involving public response by year in the U.S.

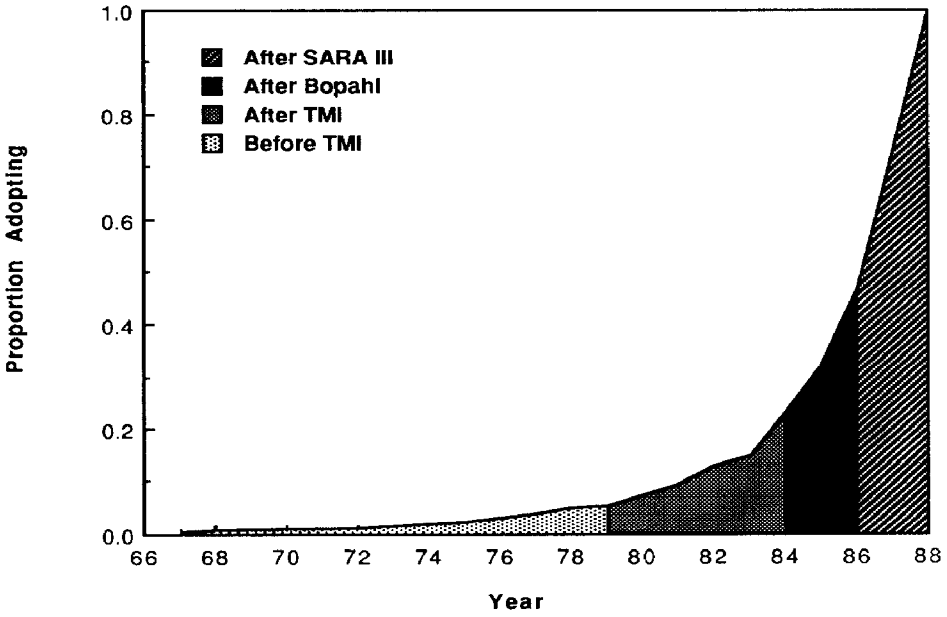

Fig. 2. Adoption of chemical annex to emergency plans by year.

Emergency planning organizations also responded to the Bhopal accident and the increasing frequency of chemical accidents. Figure 2 presents the distribution of communities adopting chemical annexes to their emergency plans by year. This distribution is arbitrarily partitioned by the occurrence of the Three Mile Island nuclear accident in 1979, the Bhopal accident in 1984, and Superfund Reauthorization and Reallocation Act (SARA) of 1986. Title III of SARA requires communities to develop emergency response plans for fixed-site facilities that store hazardous chemicals. The curve depicts the typical early stages of a logistic diffusion process. Prior to 1979 there were few adopters of an emergency plan for chemical hazards. Approximately 70% of the communities reported the adoption of chemical annexes to their emergency plans after the accident at Bhopal.

Early adoption hypotheses

Research on the diffusion processes have focussed on two levels of analysis: individual and organizational [2]. Diffusion of innovation among individuals has been characterized as a mass communication or hypodermic model, where extensive propaganda and media campaigns heavily influence decisions, and/or as a contagion or two-step flow model where opinion/action leaders influence the decisions of others [3,4]. Granovetter [5] argues that even relatively weak ties in a social network provide important channels of information that exert a powerful influence on decisions. Diffusion among individuals places emphasis on the concept of opinion leader [6]. Rogers [2] categorizes the attributes of innovators and characterizes the people choosing to innovate at various stages of development.

It is argued that organizational innovativeness is the result of the innovative character of the individuals in the organization, the internal structure and resources of the organization, and/or the external context of the organization. For example, when innovative individuals are in leadership roles of an organization and the organization is highly centralized, the organization is likely to be innovative.

While these explanations and descriptions of innovation process provide context, they are of limited utility in understanding the diffusion of planning practices among loosely connected organizations. Individual models are limited because they fail to recognize organizational constraints. Organizational models cannot be applied directly to groups of organizations. Conceptually the diffusion of innovation among emergency organizations is a hybrid situation requiring both the contagion aspects of the individual model, as well as the resource/constraints of the organizational model. This paper examines five hypotheses related to the adoption of planning practices associated with emergency planning and response organizations in local communities. The hypotheses reflect a synthesis of the individual and organizational theory. We have labeled these as the innovation, resources, necessity, vicarious experience, and professionalism hypotheses.

The innovation explanation posits that adoption decisions are influenced by individual innovation decisions (innovative personalities), and the chain-reaction of innovation through social networks that communicate the effectiveness of adoption (communication among peers) [7]. Innovative emergency organizations are more likely to adopt new planning practices than non-innovators. By virtue of their innovative character or the organization's internal and external structure, innovators are also more likely to adopt the use of new technologies than non-innovators. If the use of state-of-the-art planning practices among emergency managers is a function of innovative character or structure, emergency organizations using these planning practices will be more likely than non-users to have state-of-the-art warning systems and communications systems.

Another explanation posits that innovative planning practice decisions are limited by, if not a function of, available resources. For example, Cyert and March [8] find that the availability of uncommitted resources or organizational slack generally increases innovativeness in organizations. Quarantelli [9] finds that community preparedness is less likely in sparsely populated areas which are often characterized by a weak resource base. Although some planning practices (e.g., the development of communication protocols) are nearly "cost-free", most still require personnel to implement. If the adoption and use of state-of-the-art planning practices among emergency organizations is a function of available resources, communities with greater resources (e.g., larger jurisdictions) will be more likely to use state-of-the-art emergency planning and management practices. Or put another way the more resources available, the more planning practices will be adopted.

Another explanation is based on the fundamental relationship between necessity and invention. Effective emergency planning organizations tend to perceive a high probability of a disaster [10,11]. This explanation argues that as needs exceed capabilities new and more effective approaches are sought to more fully meet these demands. If the use of planning practices among emergency organizations is a function of necessity, communities using state-of-the-art planning practices will be characterized by fewer emergency management personnel (lower capacity), more chemical facilities (higher burden), or have higher burden-to-capacity ratios than non-innovative organizations. Emergency preparedness depends on the level of perceived threat [12]. In emergency planning and management, necessity can also be characterized in terms of protection that must be provided. Hence, as population-at-risk (PAR) increases, the community's need for protection (necessity) also increases. Hence, the necessity explanation posits that communities employing state-of-the-art emergency planning and management practices will have higher PAR's than non-innovative communities. This hypothesis implies that the adoption of emergency planning practices associated with chemical emergencies reflects a response to precipitous events; it is not difficult to imagine a dramatic chemical emergency, or "near-miss" in the area focussing public and organizational attention on preparing for similar events in the future. Emergency preparedness has been found [9] to depend on level of threat and how that threat is defined.

Tierney [12] finds that emergency preparedness depends on the technical capabilities of the people. The adoption of state-of-the-art planning practices in emergency management may be the function of organizations acquiring requisite skills for emergency planning through experience such as the involvement in prior emergency management programs. As people in the organization become proficient in these skills, their experience and knowledge of these tools facilitates the transition in applying these tools to the problems associated with chemical hazards. Having warning systems associated with other emergency management programs (i.e., civil defense, nuclear power plant preparedness, or flashflood preparedness) indicates exposure to other emergency planning practices. Hence, it can be argued that organizations with previous experience with these programs are more likely to adopt state-of-the-art planning practices.

The professionalism explanation posits that decisions to use state-of-the-art emergency planning practices are based on organizational judgments of proficiency and competence. Quarantelli [9] suggests that the lack of professional personnel and organizational leadership may hinder emergency preparedness for chemical emergencies. Innovative practices are seen as increasing the effectiveness of emergency planning and response organizations, and are adopted because they are perceived to enhance the organization's ability to respond. In other words, decisions to adopt are part of the professional character of the emergency planning and response organization. If use of state-of-the-art planning practices among emergency organizations is a function of professionalism, communities using them are expected to be more likely to have assigned responsibility for planning, have a lower proportion of volunteers, and a higher proportion of full-time-paid personnel than communities not using state-of-the-art planning practices.

Data and methods

Title III of the Superfund Amendments and Reauthorization Act (SARA) requires facilities that store, use or produce certain (listed) chemicals to report the quantities of these chemicals to the local officials responsible for community emergency planning. Under Section 305b of Title III, the U.S. Environmental Protection Agency (EPA) was required to prepare a Report to Congress reviewing the current emergency response systems for chemical accidents [13]. The EPA commissioned a survey of communities to provide the basis for this report from the community perspective. The data concerning planning practices were collected as an integral part of this larger survey of emergency management capabilities. The larger survey of communities employed a matched-pairs research design, which matched communities with previously selected chemical facilities [14,15] and allowed the overall capabilities survey to be used to interpret the results of the community study in the full context of the potential hazards faced. The design also provided a set of communities with a full range of facility types with respect to chemical used, quantities handled, size, age and release experiences. A second survey was undertaken to provide results generalizable to the nation's preparedness for chemical hazards associated with fixed chemical facilities. The results of this random sample of 500 communities represent the state of community preparedness for fixed-site chemical emergencies.

Sampling and response

For the December 1987 survey, the sample was comprised of political jurisdictions responsible for emergency planning for a release from a site selected in the sample of chemical facilities. Selected facilities were matched to local emergency management agencies in the Federal Emergency Management Agency's Hazard Identification Capability Assessment and Multi-Year Development Plan (HICAMYDP) data base. From the initial list of 525 selected facilities, 248 municipal or county jurisdictions were matched by first matching on place name and then on county of location. Of the remaining 276 facilities, 61% were eliminated as duplicate facilities for a single municipality, and 25% were duplicates at the county level and eliminated. Of the remaining 39 facilities that did not match the HICAMYDP data base, appropriate local emergency management organizations were identified for 29 facilities, resulting in a total sample size of 277 local emergency planning organizations matched with chemical facilities sampled by the EPA.

The questionnaires were mailed to the chief or head of the local agency responsible for emergency planning in each local jurisdiction in the community sample. Instructions were included to have the recipient give it to the appropriate person in the jurisdiction or area who was in charge of emergency planning for the facility. For the December 1987 survey, follow-up letters were sent to all communities not initially returning the questionnaire. Responses from 59.5% of the December 1987 sample were received; however, 23 communities either did not have or no longer had the reference facility, and five responses consisted of plans or letters only and were not coded.

For the June 1988 survey, a simple random sample of 500 communities was selected from a total of 2176 communities reporting a significant fixed site chemical hazard in their community. Seven additional communities were added to represent communities near each of the eight sites in the continental United States that store the unitary chemical weapons stockpile [16–18]. Those communities that were sampled as part of the first survey, 99 in all, either through their response that "this survey was no longer applicable to their jurisdiction", or by completion of the instrument were simply included in the second survey using their response to the first survey. No community that refused or failed to respond to the first survey was given the opportunity to respond to the second survey. The resulting sample size was 507, with 34 of the randomly selected communities having completed the first survey, and 65 either failing to respond to the first survey, or indicating it was not longer applicable in the jurisdiction.

The resulting 408 surveys comprising the second survey were mailed June 27, 1988. For a variety of contractual and organizational reasons, the follow-up letters to all communities that had not yet responded were not mailed until August 31, 1989. This placed the burden for the completion of the survey at precisely the same time as the October 17, 1988, SARA-Title III deadline. Many officials called us to apologize that they had taken so long and to ask that we accept their response after the deadline. A total of 169 of the 408 surveys mailed were returned (41.4%). Combining these with the 34 of 99 that were completed during the December 1987 survey and re-sampled by chance, and the 21 that responded that the survey no longer applied to their jurisdiction results in a 44.2% response rate. While the response rate is less than anticipated, it is probably associated with the delays in sending the follow-up letter, and the shifting of the burden to the critical time period associated with the legal requirements of SARA Title III.

Measuring planning practices

Data was collected in the surveys on various elements of each of the groups of practices. Measures of the level of adoption for each group was constructed by summing the number of practices by each community within the group and then normalizing the score between zero and one. In this fashion 5 indices were constructed.

An overall measure of planning practices was operationally defined as the average of the composite indices of plans, resources, protocols, coordination and cooperation, and computer use. The resulting variable ranges from zero to one conceptually, and 0.07 to 0.9 empirically, with a mean and standard deviation of 0.46 and 0.16 respectively.

Plans are the backbone of a community's emergency preparedness program. The plan(s) variable is operationalized as the average of binary variables representing the existence of a general emergency plan, a section on chemical hazards, a special plan or annex for a reference facility in the community's jurisdiction, and the adoption or revision of the chemical plan after 1985. The resulting variable ranges from zero to one both conceptually and empirically, with a mean and standard deviation of 0.73 and 0.24 respectively.

The existence of emergency response resources is a direct measure of existing capabilities in the community. Response resources are operationalized as an average of binary variables representing the existence of technical assistance or expertise, a fire team, an emergency response team, a hazardous materials team, a decontamination team, medical personnel, decontamination equipment, monitoring equipment, and protective equipment. The resulting variable ranges from zero to one both conceptually and empirically, with a mean and standard deviation of 0.50 and 0.27, respectively.

Written protocols guide the conduct of critical functions in emergency response, focussing on the implementation of critical functions such as particularly important decisions, and communication between critical elements of the emergency response. Written protocols and procedures are operationally defined as the average of binary variables representing the existence of written decision making protocols for issuing a warning to the public and recommending an appropriate protective action, and written procedures for issuing an alert/warning to the public generally and specifically for the reference facility, and written message protocols for communicating with the public and institutional facilities. The resulting variable ranges from zero to one both conceptually and empirically, with a mean and standard deviation of 0.29 and 0.27, respectively.

Cooperation and coordination with interested parties to provide an integrated emergency preparedness program involves establishing and maintaining relationships, people, and organizations that are likely to be involved in emergency response. Cooperation and coordination is operationally defined as average of binary variables representing community representation on the Local Emergency Planning Committee for the area, using information provided by the Chemical Manufacturers Association's Community Awareness/Emergency Response (CAER) program, conducting recent emergency exercises, having been provided information from the reference facility regarding the hazardous chemicals at the facility, and having on-going coordination of emergency planning with the reference facility and other communities in the area. The resulting variable ranges from zero to one both conceptually and empirically, with a mean and standard deviation of 0.58 and 0.25, respectively.

Using computers for emergency preparedness involves making preparations for potential emergencies in advance (planning), and directing the response to an emergency while it is occurring and in its immediate after math (management). For example planning use would be communities using computers to develop detailed inventories of hazardous materials in the area, or compile inventories of response capabilities, equipment, and personnel. Management use of computers might be using computers to assist in emergency communications and dispatch, or to map the locations of hazardous materials and response capabilities and resources, or simply to provide prioritized response check-lists. Respondents from each community were asked about the extent of their community's use of computers. Operationally, computer use is defined as the average of binary variables representing use of computers for emergency planning and management, and the specific use of software designed for emergency management and chemical dispersion modelling. The resulting variable ranges from zero to one both conceptually and empirically, with a mean and standard deviation of 0.23 and 0.24, respectively.

Measuring early adoption hypotheses

The innovation hypothesis implies that emergency managers who use sophisticated emergency planning practices would also be more likely to have state-of-the-art warning systems and communications systems. Emergency warning systems are considered state-of-the-art when they generally rely on adequate fixed (permanently installed) mass warning devices (e.g., sirens, strobes and public address systems) and/or devices that contact people more individually (e.g., tone alert radios, radio pagers, and automatic telephone dialers). Considered non-innovative are systems relying on portable sirens and public address systems, the emergency broadcast system and NOAA weather radio. Communications systems are considered state-of-the-art when equipment in the Emergency Operations Center include a 911 emergency telephone system, dedicated telephones to the reference facility, automatic ring-down systems, or a computer link with the facility. Non-innovative communications are characterized by regular commercial telephones, manual alarms, and radio communications.

The available resources hypothesis implies that communities with greater resources (e.g., larger and well funded jurisdictions) will be more likely to adopt sophisticated emergency planning and management practices. Two indirect and one direct measure of available resources are tested. The indirect measures are relatively weak, potentially confounded and provide results that are difficult to interpret solely in terms of the available resources hypothesis. One indirect measure argues that cities are generally experiencing fiscal difficulties, hence, they are expected to have fewer resources available for emergency management than county, and city-county jurisdictions. The other indirect measure argues that because available resources are directly associated with population, population size of the jurisdiction is an indicator of resources. Finally, fiscal resources at the community level and for emergency planning and management represent direct measures of resources.

The necessity hypothesis implies that planners using state-of-the-art planning practices will be characterized by fewer personnel (lower capacity), more chemical facilities (higher burden), or have higher burden-to-capacity ratio than non-users. In addition, as population-at-risk (i.e., PAR within a mile and PAR within 5 miles) increases, necessity is deemed to increase. Moreover, as the evaluation of risk associated with fixed chemical facilities increases, the emergency planning practices are likely to increase. Historical occurrences of emergency events and the hazard assessment are indicators of the communities necessity. Hence, it is postulated that communities using sophisticated planning practices are likely to have higher PAR's than communities not-using them.

The vicarious emergency planning experience hypothesis implies that communities that have warning systems associated with other emergency planning programs will be more likely to adopt state-of-the-art planning practices for chemical emergencies. Hence communities having warning systems associated with other emergency management programs (i.e., civil defense, nuclear power plant preparedness, or flashflood preparedness) will be more likely to adopt planning practices.

The professionalism hypothesis implies that communities employing sophisticated planning practices will be more likely to have a lower proportion of volunteers and a higher proportion of full-time paid personnel than communities using less sophisticated planning practices. In addition, these communities are likely to have more people (larger organizations) involved directly in emergency planning. The proportion of volunteers and full-time paid personnel are represented in terms of total emergency personnel available to respond to a chemical accident at the reference facility.

Composite and factor indicators

In addition to examining each of these individual indicators associated with the innovation hypotheses, this paper constructs composite indexes associated with each explanation. These composite indicators are defined via two alternative methods: a Boolean summation of small numbers of binary variables, and a factor analysis using principal components. Innovation hypotheses represented by a few binary indicators revolving around a central concept are combined using Boolean summation (i.e., innovation in other areas and vicarious exposure to other emergency planning programs). A value of one represents having one of the sophisticated warning or communications systems, or being involved in one of the identified emergency preparedness programs, respectively. Factor analysis of the innovation hypotheses represented by more continuous variables, revolving around divergent aspects of the underlying concept, is used to represent the underlying concept. The correlation of individual and principal components indicators of financial resources, necessity, and professionalism are presented in Table 1.

A factor analysis of indicators associated with available resources results in two components. The principal component of available resources is positively related to individual financial resource indicators. Individual variables summarizing total budget available are highly correlated ($r > 0.9$), while indicators representing spending decisions or per capita spending are weakly related ($0 < r < 0.15$). The second factor of available financial resources is weakly associated with total budget indicators ($0 < r < 0.1$) and negatively associated with indicators representing spending decisions and per capita expenditures ($r < -0.7$). This analysis of the factor space seems to conform to a total budget, spending decision/per capita budget pattern.

A factor analysis of indicators associated with necessity results in two components. The principal component of the necessity indicators is positively associated with individual variables that represent the risk or hazard assessment ($r > 0.4$), and more weakly related to variables representing past experience with hazards ($0 < r < 0.35$). The second factor is negatively associated with indicators of risk or hazard assessment ($r < -0.25$), and positively related to prior experience with chemical emergencies ($r > 0.4$). While these associations are less clear than those involving local government fiscal resources, there does appear to be dual elements of necessity associated with typical risk and hazard assessment variables on the one hand and previous emergency experience on the other. This may be a consequence of the inherent relationship between prior experience and hazard assessment.

The factor analysis of indicators associated with professionalism also results in two components. The principal component of professionalism is positively associated ($r > 0.4$) with individual indicators that represent the proportion of FTEs in emergency response organizations in the community, and the number of paid FTEs in the emergency planning organization, while negatively associated ($r < -0.7$) with the proportion of volunteers and the number of part-time employees. The second professionalism factor is positively related ($r > 0.6$) to the number of full- and part-time employees, and weakly related ($0 < r < 0.15$) to the proportion of volunteers and FTEs. These associations indicate the first factor, associated with full-time commitment to emergency management in the

TABLE 1

Correlation of individual characteristics and factor scores representing alternative hypotheses

Resources	R(1)	R(2)	$/PopN	Police	Rev$	Pub. saf.	Exp$
R(2)	0.003						
$/PopN	0.142	−0.738					
Police$	0.985	0.016	0.136				
Revenue$	0.995	0.049	0.117	0.992			
Pub. safety	0.120	−0.731	0.115	0.098	0.073		
Expend$	0.995	0.047	0.119	0.993	1.000	0.074	
PopN 1980	0.935	0.097	0.027	0.867	0.905	0.091	0.904

R = available resources (factors 1 and 2), where (1) seems to be total budget and (2) seems to be per capita/proportional

Necessity	N(1)	N(2)	PopN < 1	PopN < 5	Em < 5	#Evt	#W	#Evc	P(H/y)	Fac
N(2)	−0.003									
PopN < 1	0.428	−0.373								
PopN < 5	0.076	−0.120	0.275							
Emer < 5y	0.816	0.269	0.148	−0.011						
#Events	0.232	−0.100	0.024	0.014	0.167					
#Warn's	0.430	0.735	−0.020	−0.028	0.392	0.014				
#Evac's	0.098	0.431	0.000	−0.006	0.079	−0.003	0.076			
P(Haz/y)	0.617	−0.411	0.187	0.033	0.319	0.119	−0.043	−0.045		
Facilities	0.470	−0.363	0.102	0.018	0.199	0.331	−0.029	−0.015	0.178	
Fac/FTE	0.356	−0.277	0.022	−0.001	0.158	0.155	−0.033	−0.013	0.113	
	0.831									

N = necessity (factors 1 and 2), where (1) seems to be risk related and (2) seems to be experience based. PopN < *i* means number of people within an *i* mile radius

Professionalism	P(1)	P(2)	P(vol)	P(FTE)	Paid < FTE
P(2)	0.000				
P(Vol)	−0.705	0.125			
P(FTE)	0.791	0.020	−0.346		
Paid < FTE	−0.419	0.605	0.091	−0.151	
Paid FTE	0.429	0.758	−0.070	0.177	−0.045

P = professionalism (factors 1 and 2), where (1) seems to related to full-time employees and (2) part-time and voluntary people

community, is relatively robust, but that the second factor, associated with numbers of paid part- and full-time employees engaged in emergency planning is marginal.

Planning practices

This paper identifies five fundamental groups of planning practices: emergency plans, existing resources to respond to an emergency, specific written protocols for decisions and procedures for actions, cooperation and coordination with other interested parties, and the use of computers for emergency planning and management. Figure 3 summarizes the distribution of each planning practice and the composite and individual elements of planning practices. Previous research identifies similar types of planning elements as good planning practices and activities [19,20]. On average communities have adopted

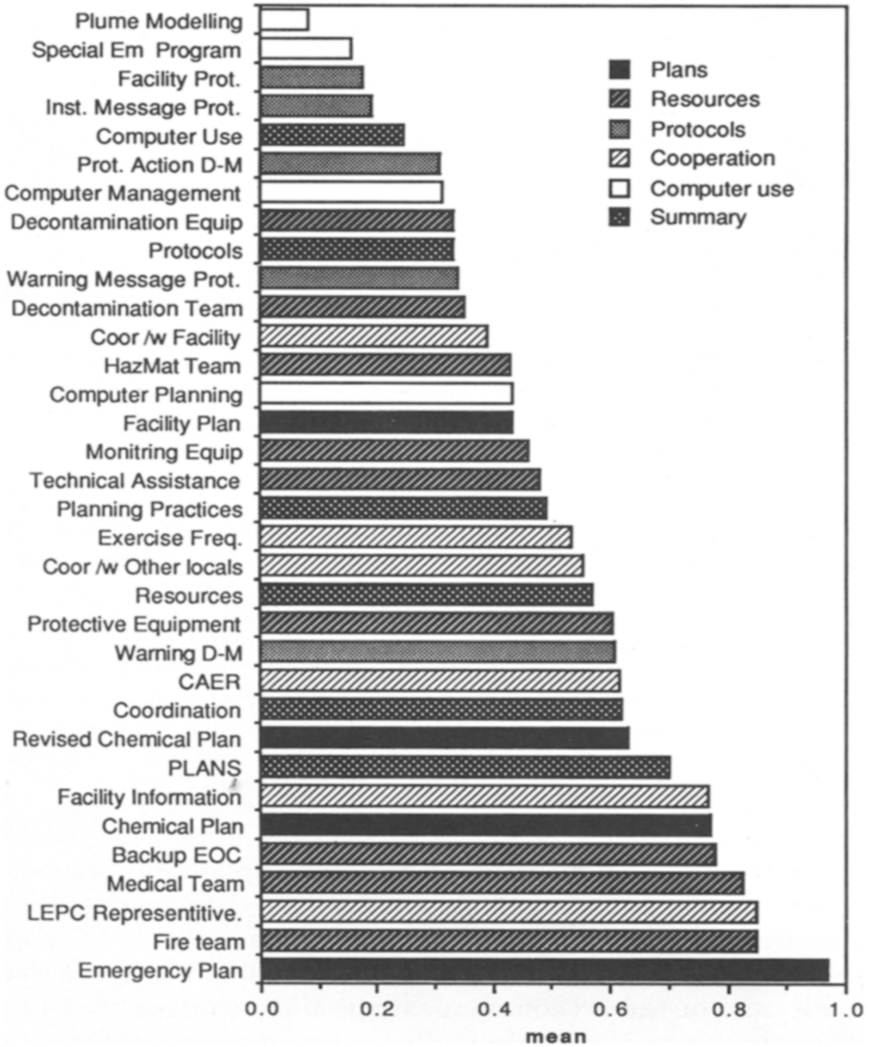

Fig. 3. Emergency planning practices and components.

just under half (0.46) of the planning practices examined. Nearly all communities have an emergency plan, but very few have adopted the use of computers to model plume exposure. Plans of all types are the most commonly adopted planning practice, while the use of computers for emergency management is the least frequently adopted. Having a plan specifically for the reference facility is the least often adopted planning practice involving plans. Using a computer for emergency planning is the least often adopted planning practice involving computer use.

Over half (0.56) of planning practices involving coordination and cooperation with other interested parties were adopted by the communities sampled. Being represented on the LEPC is the most frequently reported planning practice involving coordination, while ongoing coordination with the reference facility is the least often reported planning practice in this regard. About half (0.50) of the emergency response resources planning practices have been adopted by communities. A fire team is the most frequently reported emergency response resource, being adopted by more than 4 out of 5 communities, while decontamination teams and equipment the least often adopted planning practice associated with response resources. Less than a third (0.29) of the planning practices associated with adoption of written protocols and procedures are reportedly adopted by the communities examined. The most frequently adopted protocol or procedure involves the decision making protocol for emergency warnings, while the least frequently reported protocol or procedure involves the warning for the reference facility.

Findings

Table 2 represents the zero-order Pearson correlations of planning practices, the principal elements of planning practices and individual indicators associated with each hypothesis. As would be expected the correlation among the component indicators of planning practices are relatively high. In addition, those elements least correlated with planning practices are the most extreme, with either the vast majority of communities adopting (plans) or not adopting (computer use). Conversely, the highest correlations are among those elements closer to planning practices in Fig. 3.

Innovation

If innovation is related to the adoption of emergency planning practices among communities, emergency managers that have adopted innovative state-of-the-art communications and warning systems will be more likely to adopt planning practices. The individual level correlations in Table 2 indicate that the adoption of both state-of-the-art communications and warning systems are positively related to planning practices, but only the use of sophisticated communications systems are significantly related ($r=0.35$). Having sophisticated

TABLE 2

Correlation of indicator of innovation and planning practices (PP)

	PP	EP	R	P	CU	CC
Emergency plans (EP)	0.517~					
Resources (R)	0.697~	0.126~				
Protocols (P)	0.676~	0.231~	0.357~			
Computer use (CU)	0.548~	0.061	0.254~	0.181~		
Cooperation & coordination (CC)	0.728~	0.260~	0.424~	0.352~	0.264~	
Innovation						
State of art:						
Warning system	0.060	0.063	−0.026	0.044	0.021	0.096~
Communication system	0.350~	0.066	0.363~	0.289~	0.172~	0.201~
Available resources						
Government-Expenditures						
Total	0.111~	0.086	0.145~	0.004	0.055	0.059
Public safety	0.091	0.081	0.133~	−0.010	0.046	0.036
% on Public safety	0.145~	−0.041	0.209~	−0.017	0.143~	0.164~
Revenues	0.110~	0.086	0.143~	0.003	0.056	0.059
Population (1980)	0.194~	0.079	0.225~	0.059	0.075	0.171~
City	0.095~	0.089	0.100~	0.060	0.053	0.003
Necessity						
Facilities	0.147~	0.066	0.213	0.060	0.061	0.057
Facilities/FTE	0.075	0.028	0.129~	0.008	0.091	−0.023
PopN < 1 mile	0.165~	0.039	0.161~	0.096~	0.087	0.136~
PopN < 5 miles	−0.014	−0.095	0.150~	−0.041	−0.019	−0.051
Emergency < 5 y	0.384~	0.045	0.378~	0.351~	0.068	0.351~
P (Chemical emergence/y)	0.314~	−0.007	0.337~	0.184~	0.148~	0.311~
# of Events	−0.005	−0.094	0.063	−0.028	−0.082	0.117~
# of Warnings	0.212~	0.104~	0.103~	0.105~	0.096~	0.266~
# of Evacuations	−0.047	0.011	−0.038	−0.048	−0.054	−0.020
Vicarious experience						
Warning systems:						
Civil defense	0.105~	−0.039	0.100~	0.141~	0.019	0.101~
Nuclear power plant	0.079	−0.094	0.079	0.209~	−0.008	0.051
Flash floods	0.086	−0.01	0.079	0.204~	−0.067	0.054
Professionalism						
Paid FTEs	0.238~	0.041	0.221~	0.124~	0.111~	0.252~
Paid PTEs	0.105~	−0.047	0.143~	0.124~	−0.037	0.137~
Proportion FTE	0.131~	0.134~	0.128~	0.040	0.103~	0.011
Proportion volunteers	−0.058	−0.028	−0.094	0.066	−0.106~	−0.023

~ Significant at 0.1 level ($\alpha < 0.1$).

TABLE 3

Correlation of planning practices (PP) and components representing alternative hypotheses

	PP	I	V	R(1)	R(2)	N(1)	N(2)	P(1)
I	0.160							
V	0.148	0.045						
R(1)	0.133	0.041	−0.031	1.000				
R(2)	−0.073	−0.039	0.000	0.003				
N(1)	0.463	−0.102	0.167	0.411	0.076			
N(2)	0.004	0.117	0.006	−0.379	0.034	−0.003		
P(1)	0.136	0.164	−0.022	0.248	−0.134	0.074	−0.108	
P(2)	0.251	0.034	0.186	0.162	0.061	0.386	−0.104	0.000

PP = planning practices, including plans, emergency resources, protocols, computer use, and co-operation and coordination.
I = innovation in terms of state-of-the-art communication or warning systems.
V = vicarious experience in terms of warning systems associated with previous emergency programs.
R = available resources (factors 1 and 2), where (1) seems to be total budget and (2) seems to be per capita/proportional.
N = necessity (factors 1 and 2), where (1) seems to be risk related and (2) seems to be experience based.
P = professionalism (factors 1 and 2), where (1) seems to related to full-time employees and (2) part-time and voluntary people.

communications systems are positively related to four out of five of the components of planning practices, excluding only emergency plans. The positive correlation ($r = 0.16$) between the use of either a sophisticated warning or communication system(s) at the composite level, and planning practices (Table 3) seems to indicate that innovation in other areas is associated with the adoption of state-of-the-art planning practices as hypothesized.

Available resources

If local communities adopt planning practices because financial resources are available to do so, the communities with greater resources would be more likely to adopt planning practices. Five of the six individual indicators of available resources are significantly related to planning practices including, local government revenues and total expenditures, as well as proportion spent on public safety, total population in the jurisdiction, and being a city rather than a county based jurisdiction (Table 2). Only expenditures on public safety are not related to the adoption of emergency planning practices. These five elements of available resources are all positively correlated, with coefficients ranging from 0.09 to 0.19, associated with being a city, and jurisdictional population, respectively. Each of these five indicators are positively correlated with at least one of the component elements of planning practices, and the proportion of expenditures spent on public safety is significantly related to 3 out of 5 of the components. The positive relationship between planning practices and the overall budget factor, and negative association with the proportional or per capita factor at the composite level (Table 3) indicates the potential for a more complex relationship between available resources and the adoption of planning practices than hypothesized. One explanation might be simply that larger places have more revenue to spend on planning, which suggests a threshold or intercept effect.

Necessity

To the extent communities adopt emergency planning practices as a function of necessity, these same communities will be characterized by fewer personnel (lower capacity), more chemical facilities (higher burden), or have a higher burden to capacity ratio than communities adopting fewer planning practices. In addition, indicators associated with the evaluation of the risk posed by fixed chemical facilities in the community will be associated positively with planning practices. Five of the nine individual indicators of necessity are significantly correlated with the adoption of emergency planning practices including, the number of facilities, the population within a mile of the reference facility, the assessed likelihood of chemical hazard per year, the occurrence of an emergency in the previous five years, and the number of emergency warnings in that period (Table 2). These five indicators of necessity are all positively correlated, with coefficients ranging from 0.15 to 0.38, associated with the number of facilities and the occurrence of an emergency event in the previous five years, respectively. Each of these five indicators are positively correlated with at least one of the component elements of planning practices, and the number of emergency warnings is positively correlated with each of the component elements of emergency planning practices. The necessity factor related to hazard or risk assessment, exhibits the strongest zero-order correlation with emergency planning practices ($r=0.46$). Interestingly, the second necessity factor, related to experience with hazard, is very weakly related to the adoption of emergency planning practices (Table 3). These results seem to indicate that further examination of the necessity hypothesis in the adoption of planning practices is warranted; However, the dominance of the hazard assessment factors may suggest that adoption of planning practices is more sensitive to perceived risk or hazard assessment, than to actual experience with hazard.

Vicarious experience

To the extent that vicarious experience with emergency preparedness programs is associated with the adoption of planning practices, indicators of experience with previous programs will be positively associated with the adoption of emergency planning practices. However, having had previous emergency preparedness programs associated with the civil defense program is the only measure positively associated ($r=0.11$) with the adoption of planning practices for chemical emergencies (Table 2). This indicator is also associated with three of the component elements of planning practices. In addition, all vicarious experience indicators are positively associated with the use of the protocols and procedures element of emergency planning practices. Previous experience with other emergency planning, as indicated by the composite Boolean summation of warning systems associated with programs related to civil defense, nuclear power plants, or flash flood area, is positively associated with the adoption of planning practices (Table 3). These associations suggest further examination of the vicarious experience hypothesis is warranted.

Professionalism

If the adoption of emergency planning practices is a function of professionalism, then communities adopting planning practices will have larger organizations for emergency planning, and have emergency response forces that receive compensation. Having more personnel, in the form of both full-time and part-time staff, and having a higher proportion of FTEs are positively related to the adoption of planning practices (Table 2). These three indicators of professionalism have coefficients ranging from 0.11 to 0.24, associated with the number part- and full-time employees involved in emergency planning, respectively. Each of these three indicators is positively associated with three of the components of planning practices. The factor components of professionalism, related to full-time commitment to emergency preparedness and number of people directly involved in emergency planning, are both positively related to the adoption of state-of-the-art planning practices (Table 3). While these zero-order correlations are not conclusive, the orthogonal nature of the two factors may indicate different aspects of relationship being accounted for by the two factors. These results indicate further examination of the professionalism hypothesis is warranted. Moreover, the relationship of both factors suggests a potentially more complex relationship than initially hypothesized.

Modelling results

Up to this point each hypothesis has been considered independently, with no direct comparison among the competing explanations. The significant bivariate relationships are used to select the factors most likely to effect the adoption of state-of-the-art planning practices. The variables exhibiting significant relationships with planning practices are used in two distinct regression analyses: one comprised solely of the individual indicators, and the other comprised of the composite indicators. These analyses were conducted using an iterative elimination of independent variables in a general linear model. On each successive iteration, the independent variable was eliminated that seemed to contribute the least to the overall model in terms of (a) contribution to variance explained, and (b) the potential colinearity with other indicators related to a given hypothesis. For example, if two variables contributed on about the same level to the explained variance, the variable that represented an otherwise unrepresented hypothesis was retained in the model.

The bivariate analysis of both the individual indicators and the component factors indicates that while variables related to all hypotheses are important, variables related to the necessity concept exhibit the most robust association. Variables related to the innovation and professionalism hypotheses also exhibit very robust bivariate relationships (Tables 2 and 3). The results of this process are presented in Table 4. Both the individual indicator model and the factor model are significant ($\alpha < 0.01$). The individual indicator model accounts for 28.7% of the variance in emergency planning practices, while the composite/factor model accounts for 27.1% of the variance in planning practices.

Both the factor components model and individual indicators model confirm that necessity is the most robust explanation for adoption of emergency planning practices. The greater the assessment of chemical hazards, the more likely the community is to adopt state-of-the-art planning practices ($\beta > 0.46$). The individual indicator of necessity confirms this robust relationship with three significant coefficients ($0.12 \leq \beta \leq 0.22$), and an additional marginally significant relationship with population within a mile. These individual and factor variables are positively associated with the adoption of planning practices. Hazard assessment and previous experience with hazard appear to provide significant impetus for communities to adopt planning practices to deal with potential emergencies.

Both the factor component and the individual indicator analysis confirm that innovation in terms of installing state-of-the-art warning and communication systems is significantly associated with the adoption of emergency planning among local communities. Communities having installed either a state-of-the-art warning or communication system are significantly more likely to adopt emergency planning practices in the component model, while using a state-of-the-art communication system alone accounts for a significant amount of the variation in planning practices in the individual indicators model ($0.17 < \beta < 0.20$). These results indicate that community innovation in terms of emergency planning practices is related to previous innovative behavior in the community. What remains unclear is the extent to which this is associated with innovative individuals or institutionalized innovation.

The relationship of financial resource indicators and the adoption of planning practices is also significant in both the factor component and individual indicators models. Communities that spend a greater proportion of their existing budgets on public safety (presumably these are predominated by police and fire departments) are more likely to adopt emergency planning practices than those spending less in these areas ($\beta = 0.17$). The proportion of community expenditures may represent spending decisions rather than overall com-

TABLE 4

Comparison of individual indicator (I) and factor component (F) regression models of emergency planning practices

Hypothesis/Variable		Coefficient		Std. Coefficient		2-tailed α	
F	I	F	I	F	I	F	I
Innovation							
State-of-the-art warning or communication system	Communication system	0.087	0.064	0.176	0.203	0.001	0.000
Vicarious experience							
Warning systems civil defence nuclear power or flash floods		0.035		0.098		0.065	
Resources							
Expenditures Per capita/% Factor (2)	% on Public safety	−0.017	0.008	−0.106	0.167	0.045	0.002
Professionalism							
FTE Factor (1)	% FTE	0.014	0.060	0.090	0.100	0.091	0.062
Necessity							
Risk/hazard Assessment Factor (1)	Emergency in < 5 y	0.073	0.071	0.461	0.220	0.000	0.000
	PopN < 1 mile		0.000		0.093		0.082
	# of Warn		0.031		0.120		0.036
	P(Ch Haz/y)		0.059		0.157		0.007
Model parameters							
Constant		0.376	0.327				
R^2		0.271	0.287			0.000	0.000

munity affluence. Put another way, communities that are concerned enough about public safety to spend larger proportions of the community's budget on them, are also more likely to adopt sound emergency preparedness measures than communities less committed to public safety goals. Proportional and per capita expenditures, are negatively associated with the adoption of planning practices ($\beta = -0.11$). Insight regarding the impact of financial resources on the adoption of innovative planning practices may be gained by examining relationship and differences between the measures of financial resources (Table 3). While they are negatively correlated ($r = -0.73$), the factor component is negatively driven by proportional and per capita expenditures; proportional spending on public safety has no per capita component. This suggests that the more community resources spent per person, the less likely they are to engage in state-of-the-art emergency planning practices for the existing chemical facilities in their jurisdiction. In this sense, the adoption of emergency planning practices is associated less with community affluence than with conscious decisions about how to spend available resources.

Sometimes it is as important to discuss what was eliminated from the respective models as it is to present the variables that remain. Professionalism is not as significant as anticipated ($0 < \beta < 0.1$). Moreover completely eliminating professionalism and vicarious experience from the model seems to confirm the relative lack of importance of the professionalism and vicarious experience explanations for adoption of state-of-the-art planning practices. The total available resources, including total revenues, total expenditures, total population in the jurisdiction, have little impact in the context of the model which suggests that it is more what communities do with their existing resources, than the total amount of resources that impacts the emergency preparedness for fixed chemical facilities.

Discussion and conclusions

The results of this analysis suggest that the adoption of emergency planning practices for chemical emergencies among local emergency organizations is primarily a function of necessity, innovation and decisions to use community resources for emergency preparedness. These findings are consistent with the organizational structures and strategies used by successful emergency managers [21]. The relationship among funding decisions, necessity, and innovativeness of people creating solutions with available resources underscores the process of successful management.

These findings also indicate that the community adoption of emergency planning practices for fixed chemical facilities is more complex than can be examined with the existing data. A number of factors are not accounted for in the models of planning practices adoption examined herein. For example, the concepts of a baseline established by what would be considered minimal preparations under the state and federal guidelines, or a threshold established by what might be considered typical among communities of a given size with fixed chemical facilities are not accounted for in either the individual indicators or the factor component model used in this analysis. Another factor might be the contagion among associated communities; unfortunately, the data used in this analysis have no measures of either geographical or social distance between communities, or a given community's association with any other communities.

Consider the culture and context of emergency planning organizations in local communities. Although they serve a critical protective function during emergencies, they are also tangential to everyday community life. This is consistent with Wright and Rossi [22] who find that, even among state and local political elites, dealing with natural hazards is of relatively low-salience; a trend particularly evident in communities that have limited recent experience with disasters. Unlike fire, police, welfare or even the drivers license bureau, under normal circumstances emergency planning has low visibility among the public. Thus one source of extrinsic rewards – public recognition – is lacking. Also lacking is the public pressure that faces many civil servants who perform their tasks poorly. Because emergency planning is of low priority to the public, it is also has low visibility among the policy makers and politicians who are able to dispense rewards in the form of money, recognition, status, or centrality to overall planning processes. Thus, these rewards are typically denied to emergency organizations and planners.

Why then should emergency planners take the risk of implementing innovative emergency planning practices? The data and analysis herein imply that the reason involves both a sense of how important it is to accomplish the task in terms of necessity, and an innovative spirit bent on its performance. Providing adequate emergency preparedness also carries intrinsic rewards in terms of living up to the expectations of the public, protecting the public interest.

While necessity, innovation and the use of available resources are the strongest factors in the adoption of planning practices, it is important to realize that other variables may also be at play. Because the organizations examined here are similar to other organizations one might expect adoption to be guided by similar processes. They would be expected to vary in size, structure, hierarchy, and authority. The variations in what Rogers [2] calls complexity, formalization, interconnectedness and organizational slack were not measured, even though they might be related to the diffusion of innovative emergency planning practices, because this was not the primary purpose for collecting the data. The rate of adoption of an innovation may be a function of the quality of the idea, compatibility with existing values, complexity, triability, and observability [23]. In addition he points out that adoption is hindered when an innovation has no direct observable effects. On the other hand, the organizations examined here are unique. They share a common protective function in the community; they often are tangential to everyday community operations, becoming central to the community only under emergency conditions. It is not uncommon for their authority to be limited, even under emergency conditions (e.g., with elected officials having the ultimate authority).

The above caveat notwithstanding, these data yield important insight concerning the relationship between innovation in the adoption of emergency preparedness measures and an organization's visibility to its constituents. When visibility and extrinsic rewards are lacking, innovation becomes dependent upon the innovation of an organization and its members. Perhaps most important is that emergency planning practices are not necessarily associated with total available resources, but rather with decisions about how to spend those resources.

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