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it technology replacing labor. *Harvard Business*

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USING INFORMATION SYSTEMS IN EMERGENCY MANAGEMENT

George O. Rogers, John H. Sorensen, and Jonathan A. Morell

INTRODUCTION

Although computers have been widely used in local government for a number of years, it is only recently that they have been discovered to be a useful tool in emergency planning. The adoption of computers in emergency planning and management, in general, appears to be occurring for the same reasons that other types of computers are adopted: the advent of relatively inexpensive and powerful computer systems, more sophisticated emergency managers, and a considerable body of research concerning disasters and accumulated experience with emergencies translated into software applications (Belardo & Karwan, 1986). In the past several years a large number of computerized emergency management tools have become available. In addition, more routine computer applications are employed in the ongoing office management functions of accumulating and processing information involved in emergency planning. In

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a 1984 survey of emergency managers in California, it was found that although nearly one-half of the respondents used computers, about one-third used these systems in emergencies and only 15% indicated extensive use overall for emergency management functions (Bradford & Brady, 1986). Furthermore, the survey indicated that only a few (less than 6%) used computers for more sophisticated functions such as modeling activities. As California is a relatively affluent and innovative state, one suspects that current adoption in the country may only now equal if not still lag behind this level of use.

As in other diffusion and adoption processes, some emergency planning offices have been innovators in that they have been early to adopt computerized systems. Some use these systems for assisting in the emergency planning process. Some have gone beyond planning and have developed systems to help guide response in actual emergency situations. The purpose of this paper is to analyze adoption of computers at the local government level for emergency planning and response functions.

A survey of 137 municipal and county emergency managers responsible for community response to possible releases of hazardous chemicals from fixed site chemical facilities was conducted. These data are used to document the extent of adoption and to examine hypotheses concerning the adoption of computers in emergency planning and management by local government emergency response organizations.

Five hypotheses were developed that could help differentiate adopters from nonadopters. The first hypothesis examines the explanation that adoption decisions are influenced by individual innovators and their association with others in the social structure. The second hypothesis examines the role of resources in decisions to adopt the use of computers for emergency planning and management. The third hypothesis examines the extent to which the use of computers in emergency planning and management is a function of necessity, work load and existing capacity. The fourth hypothesis examines the role of the professional character of the emergency planning and response organizations in these adoption decisions. The fifth hypothesis examines the extent to which adopting computers for use in emergency planning and management is essentially vicarious—using this equipment primarily for more routine activities and expanding the use to emergency planning and management functions.

BACKGROUND: COMPUTER APPLICATIONS FOR EMERGENCY PLANNING AND RESPONSE

A variety of computer software has been developed to support emergency managers. One category of software concerns information management. This type of software keeps track of data to support planning including emergency

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resources, contacts, data on populations at risk, special facilities in hazardous areas, relocation centers, and other information. A second category of software is prescriptive decision tools or aids that have been developed to automate or assist emergency management and decision making. Some systems integrate information management with decision support systems (Carroll, 1983, 1985).

At least five different integrated systems have been developed. The Federal Emergency Management Agency (FEMA) has developed the Integrated Emergency Management Information System for nuclear power plant emergencies and eventually for hurricanes and other applications (Jaske, 1984, 1986). This system provides the user with information on population, road networks, and environmental features. In addition, through the use of an atmospheric dispersion model, a hazard impact model, a traffic flow model, and a siren sound propagation model, the planner can simulate or model a real emergency. The information outputs can be used to predict needed evacuation zones and location of potential traffic problems. The system requires considerable input data and computer capacity.

Several integrated systems for use on a microcomputer have also been developed. A system developed for nuclear power plant accidents attempts to directly incorporate heuristic decision aids (Belardo, Howell, Ryan, & Wallace, 1983; Seagle, Duchessi, & Belardo, 1985). The Decision Support Systems Laboratory at the University of Southern California is developing the Evacuation Management System, which is a multimodule program designed to retrieve information to support decisions and to model the evacuation from an area at risk (DeBlaugh, 1986). The Emergency Information System is a PC-based system that provides multiple modules to support a variety of emergency management functions (Morentz, 1988). The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) have developed the CAMEO system for assisting in implementing emergency plans for chemical accidents and responding to chemical releases (NOAA, 1988).

Several decision models amenable to computer applications have been developed to assist local decision makers in issuing evacuation recommendations when a hurricane is approaching (Simpson, Berke, & Ruch, 1985; Berke, Ruch & Rials, 1985; Ruch, 1985; Simpson, Hayden, Garstang, & Massie, 1985). These systems are designed to produce a recommended action to the user. The Simpson et al. approach is geared to using probabilistic estimates of landfall and confidence intervals to arrive at a decision. The Ruch (1985) model, "ESTED," allows the selection of worst case assumptions regarding possible inundation and storm-timing to arrive at a decision about when to recommend action based on expected storm arrival. Berke and Ruch (1985) provide a computer simulation model oriented to more general hazard mitigation planning.

The advent of requirements for hazardous chemicals has led to a host of computer based information systems serving different requirements and uses.

About 15 are being marketed at this time, and undoubtably many more will be available in the future ("Computer Systems," 1987). Other new computer systems perform earthquake damage assessments, predict hurricane tracks and landfalls, and calculate evacuation clearance times. Current work suggests that expert systems on emergency management functions such as the allocation of emergency vehicles and resources will be available in the not so distant future (Mick & Wallace, 1986). These innovations will likely have profound effects on the management of emergencies. They can create problems and pitfalls (e.g., emergency managers "blindly" accepting computer results without concern for the inevitable uncertainty in the information) as well as provide assistance to managers in areas where rapid decision making and quick access to information are critical.

HYPOTHESES CONCERNING EARLY ADOPTION

Rogers (1983) presents an excellent summary of existing literature on early adoption in *Diffusion of Innovations*. This work focuses on the two general aspects of diffusion: diffusion among individuals and diffusion within organizations. Diffusion among individuals has been characterized as a mass communication or hypodermic model, where extensive propaganda and media campaigns heavily influence decisions, and as a contagion or two-step flow model where opinion/action leaders influence the decisions of others (Lazarsfeld, Berelson, & Gaudet, 1948; Lazarsfeld & Menzel, 1963). Granovetter (1973) argues that even relatively weak ties in the social network provide important channels of information that exert a powerful influence on decisions. Diffusion among individuals places emphasis of the concept of opinion leader (Becker, 1970). Rogers (1983) categorizes the attributes of innovators and characterizes the people choosing to innovate at various stages of development.

Organizational innovativeness is cast in terms of the innovative character of the individuals in the organization, the internal structure and resources of the organization, and 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. Kling and Iacono (1988, p. 228) argue that support for computerization stems from computerization movements that "focus on computer-based systems as instruments to bring about a new social order." Three of their specific examples of such movements are related to innovation in this context: The movement to use computers in local government jurisdictions for urban planning, tax collection, police and other services was largely supported by federal government programs in the 1960s. The move toward office automation began in the 1950s and early 1960s. Office automation has continued to grow with the advent of personal computers in the late 1970s and 1980s.

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Although these explanations and descriptions of innovations are compelling and relevant as context, they provide limited utility in directly attributing diffusion of computer use among loosely connected organizations. The individual models are of limited utility because they fail to recognize the constraints imposed by the organization. The organizational models may be relevant for individual organizations but fail to aggregate for groups of organizations. Hence, conceptually the diffusion of innovation among emergency organizations may be thought of as a hybrid situation comprising elements of both the individual and organizational literature.

This paper examines five alternative hypotheses related to the adoption of computers in emergency planning and response organizations in local communities: innovation, resources, necessity, professionalism, and vicariousness. The innovation explanation for the use of computers among emergency organizations, 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 (Coleman, Katz, & Menzel, 1957). This explanation would indicate that innovative emergency organizations would generally be more likely to adopt the use of new technologies than non-innovators. Either by virtue of their innovative character, or the organization's internal and external structure, innovators are generally more likely to adopt the use of new technologies than noninnovators. If computer use among emergency managers is a function of innovative character or structure, emergency organizations using computers will be more likely than nonusers to have state-of-the-art warning systems, communications systems and sophisticated planning for emergencies.

Because micro- and mini-computers are now available at dramatically lower prices than previously possible, local governments are able to consider adoption of these technologies (Kraemer & King, 1988). Because resources must be allocated to purchase new technologies, even as they become less expensive and more cost effective, another explanation posits that decisions to adopt new technologies are limited by, if not a function of, available resources. For example, Cyert and March (1963) find that the availability of uncommitted resources or organizational slack generally increases innovativeness in organizations. If computer use among emergency organizations is a function of available resources, communities with greater resources (e.g., larger jurisdictions) will be more likely to use computers for emergency planning and management.

Another explanation posits the fundamental relationship between necessity and invention—"necessity is the mother of invention." This explanation posits that as needs exceed capabilities new, more effective, approaches are sought to more fully meet these demands. If computer use among emergency organizations is a function of necessity, communities using computers will be characterized by fewer personnel (lower capacity), more chemical facilities (higher burden), or have higher burden to capacity ratio than nonusers. In emergency planning and management, necessity can also be characterized in terms of protection provided. Hence, as population-at-risk (PAR) increases, the community's need for protection (necessity) also increases. Hence the necessity explanation posits that, communities using computers in emergency planning and management will have higher PAR's than communities not using computers.

The professionalism explanation posits that decisions to use computers in emergency management are based on organizational judgments of proficiency and competence. Because computers are seen as increasing the capabilities of emergency planning and response organizations, computers are acquired to enhance the organization's ability to respond; decisions to purchase are part of the professional character of the emergency planning and response organization. If computer use among emergency organizations is a function of professionalism, communities using computers will 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 computers.

Another explanation for the use of computers in emergency management posits that organizations essentially acquire micro- and mini-computers to achieve objectives that are indirectly related to emergency preparedness (e.g., word processing, budget work). But that as people in the organization become proficient in the use of the equipment, their experience and knowledge of these tools facilitates the transition to applying these tools to the problems of emergency preparedness and response. If computer use among emergency organizations is vicarious, innovators will be concentrated in non-innovative applications, and tend to refrain from the use of specialized software.

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 emergency planning in that community. Under Section 305-b of Title III, the U.S. Environmental Protection Agency was required to prepare a report to Congress reviewing the current emergency response systems for chemical accidents (EPA, 1988). The data concerning community computer use were collected as 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 facilities. Additional methodology and survey results are summarized by Sorensen et al. (1988). This research design

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allowed the overall capabilities survey 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.

Sampling

Using a purposive sampling frame, the EPA selected 525 chemical facilities that use, store or produce chemicals determined to be hazardous. The sample of communities reported herein matched the selected facilities with community-level emergency management organizations. The sampling approach used here is not a random sample of all communities covered by Title III emergency planning requirements. A sample drawn from the population of all communities that meet Title III requirement was not possible at the time of the study because the universe of such communities had not been identified. In addition, a probability sample of all communities, once identified, would be likely to over-represent communities where facilities handle relatively common chemicals.

The sample is 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 eliminated at the county level. 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.

Data Collection

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

Measurement

There are two fundamental uses of computers by emergency personnel corresponding with the emergency planning and management functions. The *planning* function involves making preparations for potential emergencies in advance—to improve response should emergency events occur. For example, communities might use computers to develop detailed inventories of hazardous materials in the area, or compile inventories of response capabilities or emergency response personnel. The *management* function involves directing the response to an emergency immediately prior to, while it is occurring and in its immediate aftermath. For example, communities could 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; "Does your community use a computer in emergency planning, that is in preparing for an emergency?" And, "does your community use a computer in emergency management, that is in responding to an emergency?" Emergency managers making affirmative responses were asked for more detail about their computer use.

The innovation hypothesis for adoption of computers implies that emergency managers who use computers would also be more likely to have state-of-the-art warning systems, communications systems, and sophisticated planning for emergencies. 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 noninnovative 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. Noninnovative communications are characterized by regular commercial telephones, manual alarms, and radio communications. State-of-the-art planning is represented by the existence of a section in the community's emergency plan that deals explicitly with chemical emergencies.

The available resources hypothesis implies that communities with greater resources (e.g., larger and well funded jurisdictions) would be more likely to use computers in emergency planning and management. 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,

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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 computer users will be characterized by fewer personnel (lower capacity), more chemical facilities (higher burden), or have higher burden to capacity ratio than nonusers. In addition as population-at-risk (i.e., PAR within a mile and PAR within 5 miles) increases, necessity is deemed to increase; hence, communities using computers are likely to have higher PAR's than communities not using computers.

The professionalism hypothesis implies that communities using computers will 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 computers. Respondents were asked if someone in the community has the formal responsibility for planning for chemical emergencies. The proportion of volunteers and full-time-paid personnel are in terms of total emergency personnel available to respond to a chemical accident at the reference facility.

The vicarious adoption hypothesis implies that innovators would be concentrated in non-innovative uses of computers. Applications that are innovative would, by definition, be creative, resourceful and uncommon. Noninnovative uses are more likely to be traditional, routine and common. Computer applications may be ranked in terms of the degree of innovation, with word processing, being the least innovative, with use of spread-sheets being the next least innovative, and communications and data base uses next. Emergency applications would be considered the most innovative, with planning being the least innovative emergency application and management being the next most innovative application; and use of specialized emergency management software is considered the most innovative use of computers in local communities.

FINDINGS

About half the communities in our sample report using computers in preparing for or managing ongoing emergencies, but 48.2% do not use computers in fulfilling these responsibilities. Among the 71 communities using computers, 62.0% use computers for both planning and management functions, but 31.0% of the communities report using computers for emergency planning only, and another 7.0% have at least some computer-assisted emergency management capabilities (Table 1). Generally, the trend seems to indicate that as computers

Table 1. Community Use of Computers in Emergency Planning and Management

Does your community use a computer in Emergency Management, that is, in responding to an emergency (% of communities)?	*Does your community use a computer in Emergency Planning, that is, in preparing for an Emergency (% of communities)?*		
	No (*N*)	*Yes* (*N*)	Total (*N*)
No (*N*)	48 (66)	15 (22)	64 (88)
Yes (*N*)	4 (5)	32 (44)	36 (49)
Total	52 (71)	48 (66)	100 (137)

become available they are used during relatively normal times for emergency planning, but as emergency personnel become comfortable with these technologies, computers are used in emergency management as well. Most communities reporting computer capabilities only for emergency management report using computer-aided dispatch systems, and others report having hazard detection systems and hazard assessment capabilities.

Innovation

If diffusion of computer use among emergency managers is a function of innovation, emergency managers that use computers would also be more likely to have state-of-the-art warning systems, communications systems and sophisticated planning for emergencies. Communities engaged in the use of computers in emergency management have state-of-the-art warning systems 5.5% more often than those not using computers; they engage in state-of-the-art planning practices 13.6% more often than noncomputer user communities; in contrast computer users have state-of-the-art communication systems 19.8% less often than noncomputer users. However, none of these differences is significant. In fact, when it comes to communications equipment in the emergency operations center (EOC), on average 19.8% fewer communities using computers report having state-of-the-art communications capabilities; this trend is also not significant. Hence, none of the measures of innovation were found to be significantly related to using computers for emergency planning and management. The *t*-tests for these hypotheses are presented in Table 2.

Table 2. Bivariate T

Hypotheses	*Using Co (N =*
Innovation (In Percent)	
Warning system	70.
Communication system	53.
Planning	77.
Resources	
Cities (In Percent)	26.
Population ($x10^{-3}$)	210.
Gross revenue ($x10^{-3}$)	97.
Expenditures ($x10^{-3}$)	
Total	99.
Police	6.
Necessity	
Facilities	157.
FTE's	9.
Facility/ FTE's	55.
Facility/ All Personnel	2.
Population ($x10^{-3}$)	
Within 1 mile	3.
Within 5 miles	51.
Professionalism (In Percent)	
Volunteers	18.
Full-time	28.
With assigned responsibility	98.

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Table 2. Bivariate Test of Diffusion Hypotheses

Hypotheses	*Communities* Using Computers ($N = 71$)	*Communities* Not Using Computers ($N = 66$)	*Probability* (t-*test*)
Innovation (In Percent)			
Warning system	70.4	66.7	0.639
Communication system	53.5	66.7	0.119
Planning	77.5	68.2	0.226
Resources			
Cities (In Percent)	26.8	45.5	0.022
Population ($x10^{-3}$)	210.0	149.8	0.236
Gross revenue ($x10^{-3}$)	97.9	82.4	0.710
Expenditures ($x10^{-3}$)			
Total	99.1	86.0	0.752
Police	6.7	6.9	0.969
Necessity			
Facilities	157.2	55.2	0.177
FTE's	9.2	11.0	0.716
Facility/ FTE's	55.8	17.2	0.160
Facility/ All Personnel	2.1	0.7	0.188
Population ($x10^{-3}$)			
Within 1 mile	3.9	5.1	0.292
Within 5 miles	51.8	33.4	0.196
Professionalism (In Percent)			
Volunteers	18.6	30.3	0.004
Full-time	28.9	22.6	0.176
With assigned responsibility	98.6	84.8	0.003

Available Resources

If emergency managers use computers because computer resources are available, then communities with greater resources would be more likely to use computers. On average 58.9% more cities report using computers for emergency planning and management than county and city-county officials. Similarly, communities using computers average 40.2% more population than non-users, but the relationship is not significant. Communities using computers also average 18.8% more gross revenue, and 15.2% greater total expenditures than communities not using computers in emergency planning and management, but neither relationship is significant at the 0.05 level. Although communities using computers average 2.9% lower expenditures for police, than noncomputer using communities, police expenditures and computer use are not significantly related. Hence, the only significant finding regarding available resources is that cities use more computerbased emergency planning and management than counties (Table 2).

Necessity

To the extent that communities using computers for emergency preparations and management is a function of necessity, they will be characterized by fewer personnel (lower capacity), more chemical facilities (higher burden), or have higher burden to capacity ratio than nonusers. Communities using computers for emergency planning and management report nearly three times more facilities than noncomputer users, and about twice the number of facilities per full-time-equivalent and all personnel involved in emergency planning and management; but none of these relationships are significant at the 0.05 level. Communities using computers also report 16.4% fewer full-time-equivalent personnel than communities not using computers, but again the relationship is not significant at the 0.05 level (Table 2). As population-at-risk increases, necessity increases; hence, necessity would indicate that communities using computers are likely to have higher PAR's than communities not-using computers. Communities using computers for emergency planning and response average 23.5% lower PAR's within a mile, and 55.1% higher PAR's within 5 miles of the reference facility; neither relationship is significant at the 0.05 level (Table 2).

Professionalism

If diffusion of computer use among emergency mangers is a function of professionalism, then communities using computers will 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 computers. Emergency organizations in communities using computers are comprised of 38.6% fewer volunteers on average than nonusers. While the proportion of communities with the assigned responsibility is very high among both computer users and nonusers,

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Vic

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hypothesis would require a measure
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qualitative examination of the vicari
and 4.

Table 3. Extent and
Use by Type

Word Processing
Spread Sheets
Communications
Emergency Management
Emergency Planning
Data Bases
Other

Notes: Among those communities using computers (
of people using a particular application.
**Among communities reporting computer
reporting "daily" or "weekly" use of compute

re cities report using computers for
han county and city-county officials.
average 40.2% more population than
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and 15.2% greater total expenditures
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computers for emergency preparations
ity, they will be characterized by fewer
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nusers. Communities using computers
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bout twice the number of facilities per
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g emergency mangers is a function of
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n of full-time-paid personnel than
ergency organizations in communities
.6% fewer volunteers on average than
of communities with the assigned
both computer users and nonusers,

computer users are 16.3% more likely than nonusers to have the formal responsibility for emergency planning. Both of these findings are significant at beyond the 0.01 level (Table 2). In addition, communities using computers are comprised of 27.9% more full-time personnel on average than noncomputer users; although this relationship is not significant at the 0.05 level (Table 2). Hence, professionalism measured in terms of proportion of volunteers and the formal assignment of emergency planning responsibility is related to the use of computers for these functions.

Vicarious

To the extent that diffusion of computer use among emergency managers is vicarious, in the early stages of diffusion the communities using computers will be concentrated in noninnovative uses. A quantitative test of the vicarious hypothesis would require a measure of adoption among those communities that are using computers for emergency planning or management (e.g., time of adoption relative to other adopters). However, in absence of such data, a qualitative examination of the vicarious hypothesis is presented in Tables 3 and 4.

Table 3. Extent and Frequency of Computer Use by Type of Application

	*Extent**	*Frequency*** (%)
Word Processing	4.2	81.7
Spread Sheets	2.6	62.0
Communications	8.0	57.7
Emergency Management	6.5	50.7
Emergency Planning	6.7	49.3
Data Bases	6.5	28.2
Other	1.1	—

Notes: Among those communities using computers ($N = 71$), the extent of computer use is the average number of people using a particular application.
**Among communities reporting computer use ($N = 71$), frequency is represented as the percent reporting "daily" or "weekly" use of computers for the given application.

Table 4. Community Use of Specialized Software

	Computer Users (%)	Total Sample ($N = 137$)($N = 71$)
Emergency Planning	42.3	—
Emergency Management	36.7	—
Dispersion Modeling	18.3	11.7

Word processing is by far the most frequently used application among communities using computers; 81.7% report using computers for word processing on a daily or weekly basis. Spread-sheet applications are used daily or weekly by 62.0% of the computer users. Communications applications are used daily or weekly by 57.7% or the communities using computers for emergency planning or management. Specific emergency management and planning applications are used daily or weekly by 50.7% and 49.3% of the communities using computers, respectively. Data base applications are the least used application (28.2% reporting daily or weekly use); however, many computer users employ data base applications, without knowing it (e.g., most emergency planning and management applications are primarily data base operations).

Although raw frequency of use may reflect the deferential need for the various functions, the use of computers in these functional areas reflects a degree of innovativeness. For example, word processing is a relatively old innovation, with its beginnings in office automation, while emergency planning and management uses are more recent. Hence, the use of computers for older, more common applications cannot be rejected by the existing data, because the general ranking of the applications in terms of frequency of use are from less innovative uses to more innovative uses; this suggests that applications used by communities are concentrated among non-innovative uses. To further underscore this interpretation communities engaged in computer assisted emergency planning and management seem to be concentrated in less specialized or demanding applications. Only 18.3% reported use of a model for predicting the dispersion of chemicals in chemical accidents, while 36.7% and 42.3% reported using software designed specifically for emergency management and planning respectively. Even among the most innovative users of computers in emergency planning and management, communities are concentrated in the least specialized applications.

Modeli

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bivariate relationships are used as a
to effect the adoption of computers i
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affects in the contingency table. Spec
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context of joint effects.

The bivariate screening analysis
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e of Specialized Software

Computer Users (%)	Total Sample (N = 137)(N = 71)
42.3	—
36.7	—
18.3	11.7

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Modeling Results

Up to this point each hypothesis has been considered independently, with no direct comparison among competing explanations. The significant bivariate relationships are used as a screen to select the factors most likely to effect the adoption of computers in emergency planning and management. The significant variables from each independent hypothesis test (i.e., city/county designation, and proportion volunteering) were selected to form a contingency table of computer use (Table 4). Because almost all communities sampled have assigned responsibility, contingency tables using it were not analyzed. Log-linear models are fit to the resulting multivariate contingency tables. Log-linear analysis allows the analyst to partition the variance in the contingency table, and associate the portions of the variance with various affects in the contingency table. Specifically, it associates the variance in the contingency table with (a) the marginals of each variable in the table, (b) the direct effects of each variable on computer adoption, and (c) the indirect effects associated with relationships among other variables. This analysis draws out the relative robustness of competing hypotheses, and allows the analyst to examine the independent impacts each has on adoption in the context of joint effects.

The bivariate screening analysis of each hypothesis indicates that professionalism is the most robust predictor of computer use decisions. Both the proportion of volunteers and the assignment of formal responsibility are significantly related to computer use in the predicted direction. The effect of available resources also cannot be rejected; however, only the city measure was related to computer use in emergency planning and management. The more direct measures of resource availability (i.e., population, gross revenues, total expenditures and police expenditures) were not related to computer use. The city designation is confounded by many other elements other than available resources (e.g., organizational, jurisdictional, political) that may affect decisions about many elements of emergency response capabilities, including computer use.

Because the proportion of communities with the formal responsibility for emergency planning is very high for all communities, the proportion of volunteers is used to represent the professionalism concept. Emergency planning and response organizations that rely on volunteers (i.e., more than one-in-four emergency personnel being volunteer) are considered less professional than those with smaller concentrations of volunteers. A series of six log-linear models were fit to a multi-variate contingency table of three variables: computer use (U), city jurisdiction (C), and volunteering (V) (Table 5). Log linear models can be expressed in terms of fitted marginals that represent the variables and their interactions that are thought to be important in the prediction of the expected cell frequency. Being hierarchical,

Table 5. Computer Use, City Jurisdiction and Volunteering

Jurisdiction Designation	*Proportion Volunteering*	*Computer Use*	*Raw Frequency*	*Cell Percent*
Non-City	≤ .25	Non-User	16	11.7
		User	35	25.5
	> .25	Non-User	20	14.6
		User	17	12.4
City	≤ .25	Non-User	18	13.1
		User	16	11.7
	> .25	Non-User	12	8.8
		User	3	2.1

interactive marginal effects include the component marginals as well as lower-order interaction terms (e.g., the model CU contains the interactive term CU, and the marginal terms C, and U). In our data the highest order model is simply expressed in terms of its marginals as CUV. This model includes the effect of each variable alone and in combination with all others; this saturated model fits the data perfectly. The lowest order model is a "null" model which implies no significant effects, and contains only a constant.

Expressed in fitted marginal notation, the hierarchical models fit for this analysis include: {CU}{VU}{CV}, {CU}{VU}, {CU}{V}, {VU}{C}, {C}{V}{U}, and with a constant only. The {CU}{VU}{CV} model examines each bivariate interactive effect. This model considers the directs linkage between three pair of variables: (1) CU, computer use and city/county designation, (2) VU, computer use and volunteering, and (3) CV, city/county designation and volunteering. The model {CU}{VU} examines only the direct effects of volunteering and city/county designation on computer use; both are examined in the context of the other interactive effects and the marginal effects of each variable alone. The {CU}{V} and {VU}{C} models examine the direct effect of community designation {CU} and volunteering {VU} on computer use in the context of the marginal effects. The {C}{V}{U} model examines only the effects associated with the marginals of each variable.

The selection of a parsimonious model was achieved with a two-stage process. In the first stage, chi-square distributions are used to compare the observed frequencies in each cell of the contingency table with the frequency predicted by the model. The likelihood ratio chi-squares associated with these models are 0.14, 3.72, 8.95, 9.75, 14.55 and 812.76, respectively. Only one of these models meets the criteria of the probability of a Type I error between 0.10 and 0.35 (Bishop & Holland, 1975, pp. 324 as cited in Knock & Burke 1986, pp. 31): the {CU}{VU} model.

The second stage of the selection
its contribution to the model. Thi
significant overall and contain insig
used to select the model that best fit
meeting the model criteria discussed
Beginning with the {CU}{VU}{CV}
freedom, nonhierarchical terms in
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from the resulting sequence of mode
right). All three models have the
marginal effect associated with comp
distribution between cómputer users

Table 6. Three Log-L
Professionalism

*Model**	*CU VU*
Marginal Effects**	
Computer Use	ns
City Jurisdiction	−0.349
Volunteering High	−0.308
Direct Effects**	
on Computer Use	
City Jurisdiction	0.249
Volunteering High	−0.259
Indirect Effect**	
City*Volunteering	−0.1
Model Characteristics	
Likelihood Ratio R^2	0.99
Likelihood Ratio X^2	0.14
Probability	0.7

Notes: *U = 1 if computers are used for emergency
V = 1 if the proportion of volunteers > 0.2
C = 1 if jurisdiction is a city, else = 0
** Lambda effects for value 1 on each vari
at the .05 level unless otherwise indicated.
[a] Significant at approximately the 0.06 level.
[b] Significant at approxiomately the 0.09 level.

Jurisdiction and Volunteering

	Raw Frequency	Cell Percent
	16	11.7
	35	25.5
	20	14.6
	17	12.4
	18	13.1
	16	11.7
	12	8.8
	3	2.1

omponent marginals as well as lower-
CU contains the interactive term CU,
data the highest order model is simply
CUV. This model includes the effect
n with all others; this saturated model
model is a "null" model which implies
a constant.
n, the hierarchical models fit for this
{VU}, {CU}{V}, {VU}{C}, {C}{V}{U},
J}{CV} model examines each bivariate
the directs linkage between three pair
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(3) CV, city/county designation and
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olunteering {VU} on computer use in
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each variable.
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contingency table with the frequency
ratio chi-squares associated with these
and 812.76, respectively. Only one of
probability of a Type I error between
5, pp. 324 as cited in Knock & Burke

The second stage of the selection process examines each effect in terms of its contribution to the model. This is important because models can be significant overall and contain insignificant terms. A stepping algorithm was used to select the model that best fits the contingency table data, in terms of meeting the model criteria discussed above and containing significant effects. Beginning with the {CU}{VU}{CV} model, which has only one degree of freedom, nonhierarchical terms in the model were eliminated when the standard error of the effect parameter, lambda's, failed to meet the appropriate t-test criteria at the 0.05 level. Estimated lambda effects and model parameters from the resulting sequence of models are presented in Table 6 (from left to right). All three models have the nonsignificant hierarchically included marginal effect associated with computer use; this is a result of the nearly equal distribution between computer users and nonusers.

Table 6. Three Log-Linear Models of Resources, Professionalism and Computer Use

*Model**	*CU VU CV*	*CU VU*	*CU V*
Marginal Effects**			
Computer Use	ns	ns	ns
City Jurisdiction	−0.349	−0.297	−0.293
Volunteering High	−0.308	−0.249	−0.249
Direct Effects on Computer Use**			
City Jurisdiction	0.249	0.206[a]	—
Volunteering High	−0.259	−0.219	−0.219
Indirect Effect**			
City*Volunteering	−0.186[b]	—	—
Model Characteristics			
Likelihood Ratio R^2	0.999	0.995	0.989
Likelihood Ratio X^2	0.14	3.72	8.95
Probability	0.703	0.156	0.021

Notes: *U = 1 if computers are used for emergency planning or management, else = 0
V = 1 if the proportion of volunteers > 0.25, else = 0
C = 1 if jurisdiction is a city, else = 0
** Lambda effects for value 1 on each variable in each term in model are reported when significant at the .05 level unless otherwise indicated.
[a] Significant at approximately the 0.06 level.
[b] Significant at approxiomately the 0.09 level.

The most complex model indicates that, being a city jurisdiction increases the likelihood of using computers by (λ = .249), while employing more than one-in-four volunteers in emergency management decreases the likelihood of using computers by (λ = .259). While being a city tends to decrease the likelihood of employing volunteers (λ = .186), the effect is significant at about the 0.09 level. Since this does not meet the .05 level of significance criterion, the indirect effect (i.e., the interaction of volunteering and city/county designation) is dropped to test the next model in the sequence, {CU}{VU}. Once again the direct effects of being a city increase the likelihood of using computer (λ = .206), while employing volunteer emergency personnel decreases the likelihood of using computers (λ = .219). However, the effect of being designated a city is only significant at approximately the 0.06 level. Hence, the direct effect of being a city on computer use is subsequently dropped from the model, yielding the {CU}{V} model. The direct effects associated with the proportion volunteering on the use of computers remains unchanged. Hence, the most robust effect on computer use for emergency planning and management is the decreased professionalism associated with employing volunteers.

DISCUSSION AND CONCLUSIONS

The results of this analysis suggest that the adoption of computer technology among these community-level emergency planning and management organizations is primarily a function of professionalism. These personal and collective beliefs that staff have concerning the importance of doing a good job are related to a number of organizational structures and strategies summarized by Drabek (1987). However, the confounding association with the volunteer measure of professionalism together with the more tentative relationship with city resources suggest that available resources are also important in the adoption decision.

These results present a puzzle; however its complete solution can only be conjecture. Why is the diffusion of computer technology among community level emergency planning and management organizations primarily a function of professionalism? Why is there no impact of numerous other factors that both common sense and the research literature suggest may be important?

The answer, though speculative, lies in the unique nature of emergency planning. Consider the culture and context of emergency planning organizations. Although they serve a critical protective function, they are also tangential to everyday community life. This is consistent with Wright and Rossi (1981), 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 h
one source of extrinsic rewards—pu
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poorly.

Because emergency planning is of
low visibility among the policyma
dispense rewards in the form of mo
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es in the unique nature of emergency d context of emergency planning critical protective function, they are ty life. This is consistent with Wright among state and local political elites, ively low-salience; a trend particularly ited recent experience with disasters. e 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 policymakers and politicians who are able to dispense rewards in the form of money, recognition, status, or centrality to planning processes. Thus, these rewards are typically denied to emergency planners.

Why then should emergency planners take the risk of implementing an innovation? The data and analysis herein have helped to answer this question. "Professionalism" implies both an inner sense of how a job should be done well, and a high level of expertise in accomplishing one's job. It also carries with it intrinsic rewards for living up to the standards of one's profession. Hence the importance of professionalism, to the exclusion of many other likely important factors—in explaining the tendency to innovate.

Although professionalism is the strongest explanatory factor, it is important to realize that other variables may also be at play. Most prominently, our data concerning geographical location could be interpreted to mean that level of available resources are also important. Had the data been clearer, this factor might have emerged as also being significant. On the one hand, the organizations examined here are similar to other organizations. They would be expected to vary in size, structure, hierarchy, and authority. The variations in what Rogers (1983) calls complexity, formalization, interconnectedness and organizational slack were not measured because of the secondary nature of the data; however, these dimensions would also be expected to vary among the organizations studied. 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 adoption and an organization's visibility to its constituents. When visibility and extrinsic rewards are lacking, innovation becomes highly dependent upon the personal characteristics of an organization's members. In the case of emergency planning, it seems unlikely that rewards can be increased. Thus, high quality emergency planning requires that whenever possible, decisions should favor increasing the professional make up of planning organizations.

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REFERENCES

Becker, M. (1970). Sociometric location and innovativeness: Reformulation and extension of the diffusion model. *American Sociological Review 35,* 262-282.

Belardo, S., Howell, A., Ryan, R., & Wallace, W. (1983). A microcomputer-based emergency response system. *Disasters, 7,* 215-220.

Belardo, S., & Karwan, K. (1986), Prototyping with micro-computers: A design strategy for disaster management support systems. In S. Marston (Ed.), *Terminal disasters: Computer applications in emergency management* (pp. 29-44). Boulder, CO: Institute of Behavioral Sciences, University of Colorado.

Berke, P., & Ruch, C. (1985). Application of computer system for hurricane emergency response and land use planning. *Journal of Environmental Management 21,* 117-134.

Berke, P., Ruch, C., & Rials, D. (1985). A computer simulation system for assessment of hurricane hazard impacts on land development. In J. Carroll (Ed.), *Emergency Planning* (Vol. 15, No. 1, pp. 149-154). La Jolla, CA: Society for Computer Simulation.

Bishop, Y. M. M., & Holland, P. W. (1975). *Discrete multivariate analysis: Theory and practice.* Cambridge, MA: MIT Press.

Bradford, J., & Brady, M. (1986). Effective computer systems for emergency management. In S. Marston (Ed.), *Terminal disasters: Computer applications in emergency management* (Vol. 11, No. 2). Boulder, CO: Institute of Behavioral Sciences, University of Colorado.

Carroll, J. M. (Ed.). (1983). *Computer simulation in emergency planning* (Vol. 11, No. 2). La Jolla, CA: Society for Computer Simulation.

———. (Ed.). (1985). *Emergency planning* (Vol. 15, No. 1). La Jolla, CA: Society for Computer Simulation.

Coleman, J., Katz, E., & Menzel, H. (1957). The diffusion of an innovation among physicians. *Sociometry, 20,* 253-270.

Computer systems for emergency preparedness and response. (1987, November 23). *Environmental Manager Compliance Advisor, 219,* 5-7.

Cyert, R. M., & March, J.G. (1963). *A behavioral theory of the firm.* Engelwood Cliffs, NJ: Prentice Hall.

DeBlaugh, F. (1986). Decision support for evacuation operations using microcomputers. In S. Marston (Ed.), *Terminal disasters: Computer applications in emergency management* (pp. 45-66). Boulder, CO: Institute of Behavioral Sciences, University of Colorado.

Drabek, T. E. (1987). *The professional emergency manager: Structures and strategies for success.* Boulder, CO: Institute of Behavioral Science, University of Colorado.

Grannovetter, M. (1973). The strength of weak ties. *American Journal of Sociology 78,* 1360-1380.

Jaske, R. (1984). *FEMA's integrated emergency management information system* (draft). Washington, DC: FEMA.

——— (1986). FEMA's computerized aids for accident assessment. *Proceedings International Symposium on Emergency Planning and Preparedness for Nuclear Facilities, Rome, 4-8 November.* Vienna: International Atomic Energy Agency.

Kling, R., & Iacono, S. (1988). The mobilization of support for computerization: The role of computerization movements. *Social Problems 35*(3), 226-243.

Knock, K., & Burke, P.J. (1986). *Log-linear m*

Kraemer, K. L., & King, J.L. (1988). The role o
Government Studies 14, 23-47.

Lazarsfeld, P., Berelson, B., & Gaudet, H. (I
University Press.

Lazarsfeld, P., & Menzel, H. (1963). Mass me
The science of human communication.

Mick, S., & Wallace, W. (1986). Expert systen
Marston (Ed.), *Terminal disasters: Com*
195-204). Boulder, CO: Institute of Beh

Morentz, J. (1988). *The emergency informatior*

National Oceanic and Atmospheric Administra
Aided Management of Emergency Oper
Response Branch.

Rogers, E. 1983. *Diffusion of innovations.* Nev

Ruch, C. (1985). *ESTED.* Paper presented at t
Louisiana.

Seagle, J., Duchessi, P., & Belado, S. (1985)
application in emergency management.
No. 1). La Jolla, CA: Society for Comp

Simpson, R. H., Hayden, B., Garstang, M., &
actions. Environmental Management 9,

Sorensen, J. H., Rogers, G.O., & Clevenger,
emergencies at fixed chemical facilities (
Ridge National Laboratory.

United States Environmental Protection Agen
to Congress, Section 305[b] Title III. S
of 1986. Washington, DC: Offices of Sc

Wright, J. D., & Rossi, P.H. (1981). The pol
J.D. Wright & R.H. Rossi (Eds.), *Soci*
Abt Books.

Knock, K., & Burke, P.J. (1986). *Log-linear models.* Beverly Hills, CA: Sage.

Kraemer, K. L., & King, J.L. (1988). The role of information technology in managing cities. *Local Government Studies 14,* 23-47.

Lazarsfeld, P., Berelson, B., & Gaudet, H. (1948). *The peoples choice.* New York: Columbia University Press.

Lazarsfeld, P., & Menzel, H. (1963). Mass media and personal influence. In W. Scramm (Ed.), *The science of human communication.* New York: Basic.

Mick, S., & Wallace, W. (1986). Expert systems as decision aids for disaster management. In S. Marston (Ed.), *Terminal disasters: Computer applications in emergency management* (pp. 195-204). Boulder, CO: Institute of Behavioral Sciences, University of Colorado.

Morentz, J. (1988). *The emergency information system.* Hungerford, MD: Research Alternatives.

National Oceanic and Atmospheric Administration. (1988). *The CAMEO II Manual* (Computer Aided Management of Emergency Operations). Seattle, WA: NOAA, Hazardous Materials Response Branch.

Rogers, E. 1983. *Diffusion of innovations.* New York: The Free Press.

Ruch, C. (1985). *ESTED.* Paper presented at the National Hurricane Conference, New Orleans, Louisiana.

Seagle, J., Duchessi, P., & Belado, S. (1985). Simulation using geographical data bases: An application in emergency management. In J. Carroll (Ed.), *Emergency planning* (Vol. 15, No. 1). La Jolla, CA: Society for Computer Simulation.

Simpson, R. H., Hayden, B., Garstang, M., & Massie, H. (1985). *Timing of hurricane emergency actions.* Environmental Management 9, 61-70.

Sorensen, J. H., Rogers, G.O., & Clevenger, W.F. (1988). *Review of public alert systems for emergencies at fixed chemical facilities* (Report ORNL/TM-10825). Oak Ridge, TN: Oak Ridge National Laboratory.

United States Environmental Protection Agency. (1988). *Review of Emergency Systems: Report to Congress, Section 305[b] Title III. Superfund Amendments and Reauthorization Act of 1986.* Washington, DC: Offices of Solid Waste and Emergency Response.

Wright, J. D., & Rossi, P.H. (1981). The politics of natural disaster: State and local elites. In J.D. Wright & R.H. Rossi (Eds.), *Social Science & Natural Hazards.* Cambridge, MA: Abt Books.