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THREAT PERCEPTIONS IN ACUTE CHEMICAL DISASTERS

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ABSTRACT

This paper describes the differential perception of disaster threat exhibited by 300 organizational respondents in 19 American communities. Statistical analysis of the relationships between threat perception and selected social climate variables is conducted in an attempt to identify some of the factors that influence this differential perception of threat. In particular, the finding that three chemically related disaster agents are ranked in the top four probable community disasters is examined. Implications of this finding for chemical disaster planning are noted as well as some corrective measures which might be undertaken to improve preparedness for acute chemical emergencies.

INTRODUCTION

As part of the larger study of organizational and community preparedness for acute chemical disasters already reported elsewhere (1,2), the perception of disaster probabilities was specifically examined. Key respondents in the localities studied were asked to assess, on a scale of 0 to 5, the probability of 36 different natural and technological disasters occurring within a ten year period. A rating of 0 represented non-applicability or no chance of occurrence and a 5 indicated a perception of almost total certainty. This article reports the findings from an analysis of the 300 probability scales completed by public and private sector officials in 19 different communities in the United States. Special attention is paid to the three chemically related disaster agents rated, namely, a sudden toxic release, a chemical substance spill, and a major chemical plant explosion.

FINDINGS

The table below presents the mean probability scores of our respondents for all disaster agents. When the probability for each agent is calculated and rank-ordered from highest to lowest, the three chemical agent situations rank rather high. As the table indicates, Chemical spill (Chemspil) and Major Chemical Plant Explosion

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(Exploc) rank first and third, respectively. Sudden Toxic Substance Release (Toxic) shares the fourth-fifth rank with Plane Crash.

TABLE 1

Mean Probabilities For All Disaster Agents

N=300

Agent	$\bar{X}$	Agent	$\bar{X}$
*1. Chemical Contamination or Spill	3.78	19. Pipeline Explosion	2.52
2. Large Automobile Wreck	3.56	20. Smog Episode	2.38
*3. Major Plant Explosion-Chemical	3.31	21. Blizzard or Massive Snowstorm	2.16
*4. Sudden Toxic Substance Release	3.13	22. Forest or Brush Fire	2.13
5. Plane Crash in Community	3.13	23. Water Shortage	2.06
6. Major Plant Explosion-Other	3.12	24. Ship Disaster in Harbor/Coast	2.02
7. Major Frost And Freeze	3.01	25. Epidemic	1.96
8. Major Water Main Break	3.01	26. Hurricane	1.93
9. Water Pollution	2.99	27. Drought	1.83
10. Electrical Power Blackout	2.97	28. Radiation Fallout	1.73
11. Tornado	2.96	29. Earthquake	1.51
12. Flash Flood	2.84	30. Dam Break	1.14
13. Severe Fog Episode	2.84	31. Mud or Landslide	1.11
14. Major Gas Main Break	2.84	32. Sand/Dust Storm	.93
15. Freezing Ice Storm	2.72	33. Tsunami or Tidal Wave	.53
16. Oil Spill	2.67	34. Mine Disaster	.51
17. Major Hail Storm	2.57	35. Avalanche	.19
18. River Flood	2.56	36. Volcanic Eruption/Fallout	.07

*Chemically related disaster agents

When individual mean probabilities are calculated for each of the 19 cities, the data show that in twelve of the cities mean probabilities for all three chemically related agents are greater than or equal to 3.00, or moderately probable. Respondents from only one city think that Chemspil is less than moderately probable. Respondents in 9 of the 19 cities rate all three chemical disaster agents among the 7 disasters most likely to occur. Respondents in all but two of the cities rate at least one of the chemical agents as among the top five disaster threats that they face.

If we assume that individual perceptions of officials are indicative of their organizations' stance, this all seems to indicate a fairly high level of threat perception among disaster-relevant organizations. However, differential perception is evident among organizations and cities of different sizes.

A general hierarchy of organizational perceptions results from ranking the mean probabilities of chemical companies, police departments, and fire departments. Chemical companies rate the probabilities of the three chemically related disaster agents' occurrence lower than do police departments, who, in turn, rate them lower than do fire departments. However, the only statistically significant difference between the means for these groups is between chemical companies and fire departments. ($p < .05$)

When all organizations surveyed are classified into three distinct categories based upon similarities of function, funding sources, and interests-at-stake, differences also appear. The first category of organizations include groups from the chemical

and transportation industry. Chemical manufacturers, chemical industry mutual aid groups, railroads, and trucking firms all fit into this classification. The second general category of organizations consists of public non-emergency organizations and includes public health departments, the court system, mayor's offices, planning boards, city administrator/manager's offices, county commissioners, water and power departments, environmental protection agencies, public works departments, and building inspection agencies. The third and final category consists of public emergency organizations. Included in this category are hospitals; the Coast Guard; city, county, and state civil defense agencies; fire and police departments; sheriff departments; the state police; safety directors' offices; weather service offices; and the Red Cross.

When organizations are divided into categories according to the above criteria, differences are found to be statistically significant at the .05 level. For all three chemically related disaster agents, the chemical and transportation sector mean scores are significantly lower than the public non-emergency means. Similarly, the chemical and transportation sector means are significantly lower than the public emergency mean scores. However, the only significant difference in mean probability between the public non-emergency and emergency sectors is for Major Chemical Plant Explosion (Exploc). In other words, within our sample, the chemical and transportation industries tend to perceive the probability of a chemical disaster as significantly lower than do public non-emergency and emergency organizations.

When the 19 cities studied are divided into three categories based on population, significant differences in threat perception are also found. In two of the three chemically related disaster agents (Chemspil and Toxic), significant differences exist in the probability between the mean scores of small- and medium-sized cities. Similarly, significant differences also exist between small- and large-sized cities. The direction of the differences indicates that respondents in small cities perceive the probability of a chemical disaster as significantly lower than their counterparts do in medium and large cities. However, there are no significant differences between medium and large cities in their ranking of the three chemically related disaster agents.

From the findings reported above, it appears that there is a relatively high general perception of the probability of a chemical disaster but that specific perceptions show considerable variation, sometimes in a systematic fashion. What is responsible for these variations in perceptions? The theoretical model used in the larger study and detailed elsewhere suggests that community resources, social linkages and social climate might mediate the perception of threat (3). In this analysis, only the social climate dimension is used to attempt to explain the variations in threat perception.

It is assumed that to some degree, threat of a chemical disaster is present in every community. Operationalization of threat is accomplished in two ways, resulting

in two different threat variables. The first variable (Threat 1) is an index of three equally weighted indicators: the number of chemical plants per square mile, the number of personnel employed by the chemical industry per total work force, and the number of accidents per square mile for 1971-1977 as a measure of transportation hazards by rail or truck. The second threat variable (Threat 2) is based on the existence or non-existence of a large chemical complex and/or port facility within the community. Operationalizing the variables in this way allows us to differentiate between specialized knowledge which could be used by disaster-relevant organizations to develop a composite vulnerability index and the threat that is generally perceived due to the size of the chemical complex or port. While Threat 1 is probably specific to organizations that are concerned with the vulnerability of the community, the high visibility of a large chemical complex and port facility, or its absence, may better reflect what level of threat is common knowledge to the community.

Several social climate variables are involved in the variation in perceived threat. The social climate dimension includes social, political, economic, legal and historical conditions affecting social linkages and resources. Among these historical conditions is the natural disaster history of the community. It can be argued that a community with extensive experience in dealing with natural disasters (e.g., floods, hurricanes, tornadoes) has a heightened disaster awareness which could carry over into the technological disaster area. On the other hand, a community that has experienced little in the way of natural disasters may have a low level awareness of any disaster threat. For this reason, indicators, measuring the number of major federal disaster declarations, the severity of previous disasters in terms of dollar damage, and the number of natural disaster agents involved in federal disaster declarations for the communities studied, are used to derive a composite variable, Disaster Experience.

A social condition that may affect the perception of threat by disaster-relevant organizations is the public's expectations of a chemical disaster. Since many of the groups studied, particularly the public service organizations, are subject to public opinion pressures, it is reasonable to expect that organizational respondents' perceptions of threat are colored, to a degree, by the public's expectations. For example, in communities in which public perception is high, organizations may be able to expand their domain through increased funding and legitimization by also perceiving the threat as high. On the other hand, in the face of movements to restrict government spending and cut budgets in many publicly-funded organizations, if the public's expectations of chemical disasters are thought to be low, public organizations may also perceive the threat of such disasters as low in order to use their limited funds in activities which citizens might believe to be more important. The variable, Public Expectations, consists of an assessment by organizational respondents of the public's expectations of a chemical disaster. Although it is a rather tangential measure of public awareness, it may more accurately reflect pressures to which officials are responding than would a general survey of the public.

Two other social climate variables are used to attempt to explain the variation in the perception of threat. These variables represent the presence or absence of any systematic effort to assess the degree of fixed chemical hazards (Assess 1) and the transportation of chemical hazards (Assess 2) within the community. It can be argued that these two measures should vary in accordance with the perceived threat.

The dependent variable, Perceived Threat, is treated in two different ways in this analysis. As previously mentioned, respondents were asked to rate the probability of three separate chemical disaster agents on a scale of 0 to 5. It is possible to use each of the three agents (Chemspil, Toxic, and Exploc) as separate, dependent variables in three separate analyses, or they can be combined by taking a mean value of all three. In the former case, three separate analyses have to be conducted using a community-wide mean probability score as the level of perceived threat for each agent This is defensible in that a single chemical mishap could involve any combination of the three and that each indicator or agent, therefore, has its own probability of occurrence. In the latter case, a single analysis is conducted using a mean score of three community-wide means as the level of perceived threat for any chemical mishap. An argument can be made that using an overall community-wide mean of the probabilities of all three indicators is legitimate on the grounds that the respondents were unable to differentiate between the three or that there is sufficient overlapping (e. g., a chemical plant explosion could easily result in a sudden toxic substance release) to cause separation to be empirically impossible. For the purpose of this analysis, both methods are employed and results compared.

Due to the type of data obtained, dummy-coding of all the independent variables is required. An attempt is made to determine if linear relationships exist between the six independent variables (Threat 1, Threat 2, Disaster Experience, Public Expectations, Assess 1, and Assess 2) and the dependent variable Perceived Threat (when combined) or the dependent variables Chemspil, Exploc, and Toxic (when separated). Four seven-variable models are hypothesized (Figure 1). Employing a manual stepwise regression method, variables that do not contribute significantly to the model (p. of Type IV Sum of the Squares $<.05$) are eliminated.

When the three indicators or agents are treated as separate dependent variables a fairly consistent pattern of results is found. In the case of the dependent variable Toxic, three independent variables, Threat 2, Disaster Experience, and Public Expectations produce a significant R^2 of .97 ($p < .05$) with Threat 1, Assess 1, and Assess 2 not contributing significantly to the hypothesized models. In the cases of the dependent variables Chemspil and Exploc, the independent variables Threat 2 and Public Expectations are the only ones that contribute significantly with an R^2 of .82 and .55, respectively ($p < .05$). As can be seen, Assess 1 and 2 and Threat 1 do not contribute significantly to any model and Disaster Experience as an independent variable only contribute in the case of the dependent variable Toxic. In other words, Threat 2, Disaster Experience and Public Expectations explain 97% of the variance in the

perception of a Sudden Toxic Substance Release. Likewise, Threat 2 and Public Expectations explain 82% and 55% of the variation in the perceptions of Chemical Spill and Major Chemical Plant Explosion, respectively.

When the three indicators or agents (Chemspil, Exploc, and Toxic) are combined into the single dependent variable Perceived Threat, much the same results are found. Threat 2 and Public Expectations contribute significantly to the model with an R^2 of .88 ($p < .05$). In other words, Threat 2 and Public Expectations, together, can explain 88% of the variation in Perceived Threat. Assess 1, Assess 2, Threat 1, and Disaster Experience do not contribute significantly to the model.

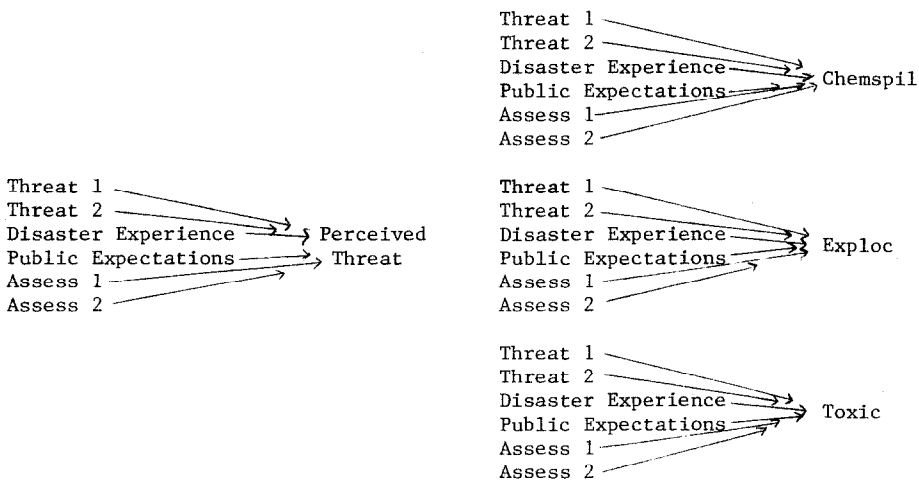

Figure 1. HYPOTHESIZED MODELS

DISCUSSION

The selection of cities, organizations and respondents in our study was not based on probability sampling techniques. The samples were purposively selected from cities known to be subject to a relatively high degree of threat from chemical hazards and from organizations that should be and usually are involved in community-wide planning for disaster preparedness. As such, the conclusions drawn from the results of the analysis might be seen as only descriptive of the 19 communities studied and not generalizable to other American towns and cities. However, any bias in the sample is likely to be in the direction of overstating threat perceptions of acute chemical disasters since known vulnerable communities and persons within them who would be sensitive to disaster planning were studied. Therefore, if there are any significant differences between the sample of cities, organizations and respondents used and the universe of all American communities, groups and officials, the findings reported may indicate greater perceptions of threat than is generally true. Bearing this in mind, it does seem reasonable to draw some general conclusions from the findings and

to derive some implications they may have for disaster planning.

It appears at first glance that respondents assigned a high degree of probability to the occurrence of the three chemically related disaster agents. By ranking the mean probabilities, the chemically related agents are shown to be among three of the four most probable disasters. However, this relative ranking may just as well reflect a low perception of all disaster threats as a high perception of chemical disasters. The perceived threat of most of the 36 disaster agents was less than moderately possible. Even taking into account the very low scores for some of the more geographically-bound agents such as avalanches, tsunamis and volcanoes, the perception of disaster threats was low in general. The highest mean probability for any agent was 3.78 (Chemspil). On a scale of 0 to 5 this is not that high a probability. Stated another way, perceptions of chemically related disasters rate high only relative to the low rating given almost all other disasters.

Nonetheless, the three chemically related agents are all near the top of the ranking. As such, it would seem to follow that if chemical disasters were perceived as having a higher probability of occurrence than other kinds of disasters, most community disaster planning would be oriented to chemical threats. However, this is not the case.

It was indicated earlier that significant differences in the perception of chemically related disaster probability exist among some types of organizations and in communities of different sizes. Chemical and transportation industry personnel tend to perceive the probability of a chemical disaster as being lower than do public non-emergency and emergency personnel. Respondents in small cities, regardless of organizational membership, tend to perceive the probability of a chemical disaster as being lower than do respondents in medium and large cities. Taken together, these two findings seem to suggest that those who are most dependent economically on the chemical industry tend to perceive the threat as being lower. Whether due to vested interests or legitimate beliefs required to maintain cognitive consonance, an implication of these findings may be that chemical disaster planning will tend to be less extensive and considered less important if left entirely to people in a dependency relationship.

It has been demonstrated that systematic schemes to assess fixed and transportation chemical hazards are not linked to perceived threat. This may well be a function of the somewhat primitive and sporadic manner in which such risk assessment efforts have generally been applied, if at all. It was also shown that natural disaster experience plays only a minor role in the perception of threat. It appears, rather, that perceived threat is more a function of the visibility of the local chemical industry than of actual community-wide involvement with the chemical industry.

The above discussion seems to suggest several things. First, a risk assessment scheme which accurately reflects the degree and nature of the hazards that exist within a community should be developed and utilized. This scheme should utilize data that is already available, although probably scattered throughout the community, as

much as possible to reduce time consumption and the costs associated with its use. The scheme should be fairly standard from community to community to facilitate inter-jurisdictional disaster responses and yet provide an accurate and complete inventory of the chemical threats within the community. Second, all organizational sectors of the community need to be involved in the process. Aside from facilitating the gathering of information necessary for a complete assessment, this should lead to some consensus among organizations as to the degree of threat that exists. The social linkages that develop from this process could also facilitate disaster planning and aid in the actual response to a chemical incident should the occasion arise. This would also tend to insure that primary responsibility for disaster planning does not fall to a group who, acting in isolation, tends to perceive threat lower than does everyone else. This, of course, rests on the assumptions that those who perceive threat as lower than others are really understating the degree of threat that truly exists and that awareness of this tendency can help to rectify the situation. And third, an education campaign seems necessary to inform the public of the nature and extent of hazards that exist. The current tendency of the chemical and transportation industries to maintain a low community profile (other than public relations-type advertising) only encourages mistrust. Oftentimes, it seems that some community organizations and the chemical industry believe it is better for the public not to know the nature and extent of the hazards they face. Why create undue stress and anxiety in citizens and subject themselves later to added public pressure? Added to this attitude is the chemical industry's concern over corporate security of chemical processes and products. These concerns sometimes block assessment efforts and tend to create mistrust among the public, the chemical and transportation industries, and public organizations. However, the chemical and transportation industries' participation in a legitimate assessment of hazards could secure the trust of the public and disaster-relevent personnel. A public education campaign could also bring a degree of consonance between public expectations and disaster-relevant organizational personnel's expectations. This would allow community officials to better conduct their activities in accordance with the actual level of threat rather than as a response to the pressure of a misinformed public. An educated public that trusts its public officials responds better and more quickly in an actual hazardous incident than does one that is caught unaware.

It seems clear that differential perceptions of threat can, at times, have serious consequences for chemical disaster planning. The disaster planning that does result from this situation often has serious consequences in regards to the quality of response to a dangerous chemical incident. Therefore, it also seems that some method of risk assessment which will produce greater perceptual consensus is a necessary first step to developing a social climate within the community that is conducive to disaster planning.

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