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Evacuation behavior and Three Mile Island

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The responses of the residents to the nuclear power plant accident at Three Mile Island, Pennsylvania illustrate the factors influencing pre-impact coping responses of populations exposed to technological hazards. Confusion and ambiguous information influenced both the decision to evaluate and to remain in place. Proximity to the facility, stage in life cycle and the actions of friends and neighbors influenced the decision to evacuate.

Key words: Evacuation, Three Mile Island, nuclear power plant accidents.

INTRODUCTION

A recent study of the Three Mile Island nuclear power plant accident of March 1979 (Zeigler, Brunn and Johnson, 1981) reports a number of generalizations about the evacuation behavior of area residents. Unfortunately, they were unable to address fully the role of spacial proximity and the social correlates of evacuation due to the limitations in the size of their data set. What we would like to do in this paper is to examine those correlates. Findings from our study of the responses of the affected population reveal some statistically significant associations between evacuation and socio-spacial variables.

Three Mile Island (TMI) was the first example in the United States of a widespread, voluntary evacuation associated with a nuclear mishap and thus it can be used as a case study of what prompts evacuation when residents have no clear knowledge of the consequences posed by the threat. Several factors influence individual coping responses to such threats, including prior experience with the hazard in question, the material wealth of the individual, personality variables, confirmation of hazard warning, age and stage in the life cycle, and the actions of friends and neighbours (Burton, Kates and White, 1978; Quarantelli, 1980; Quarantelli and Dynes, 1978). Other research on the spacial aspects of evacuation, on risk assessment, and on evacuations following disasters has expanded our knowledge of what prompts voluntary evacuations under various conditions of uncertainty (Baker *et al.*, 1976; Whyte, Liverman and Wilson, 1979; Perry, 1981).

Many generalizations found in the natural hazards and disaster literature may not be applicable to technological hazards. For example, limited experience cannot influence evacuation in unprecedented situations; no experience may also increase the fear of the unknown and prompt evacuation. There is uncertainty regarding impacts on health and that could influence the choice of coping responses. Personality factors influence an individual's assessment of risk. The lack of prior knowledge regarding the extent and consequences of the hazard necessitates an immediate decision under extremely stressful conditions.

We suggest that four factors, as gleaned from our data and analysis, are significant influences on voluntary evacuations from technologically hazardous situations: (1) confirmation of the hazard information; (2) spacial proximity to the hazard; (3) social status; and (4) social influence. Ambiguous information, as it relates to the inability to confirm the hazard threat, and proximity to the hazard source are hypothesized as the most important influences prompting evacuation.

STUDY DESIGN

Residents in the vicinity of TMI were surveyed in April, 1979, using a mailed questionnaire. They were asked a series of questions relating to their knowledge of the event, reliability of information sources, risk assessment, coping responses, and social characteristics. Of particular importance were the questions regarding the nature and extent of evacuation. If the respondents indicated they left the area during the crisis, evacuation information sought included: (1) time of departure; (2) specific cues leading to evacuation decision; (3) destination; (4) reasons for destination selection; and (5) date of return. If the respondents did not evacuate they were asked to explain why.

The sampling plan consisted of a stratified random sample based on direction and distance from TMI (Fig. 1). The area was divided into 5 mile concentric zones around the reactor and four quadrants (N, S, E, W), resulting in 20 sampling units. Telephone directories were used to obtain the names and addresses of potential respondents. The initial sample size of 1,000 was reduced to 922 because many questionnaires were undeliverable. A total of 359 questionnaires were returned, a response rate of 40%. There was no followup letter. A more complete discussion of the survey design, including study limitations, can be found in a preliminary report on the responses of the affected populations to the accident (Barnes *et al.*, 1979; Cutter *et al.*, 1979).

Approximately 39% (140) of the respondents in our sample evacuated themselves and/or their families from the area during the crisis. The majority of evacuees (54%) left the area on Friday, 30th March, following Governor Thornburgh's advisory evacuation statement. The advisory recommended that pregnant women and preschool-age children within 5 miles of the reactor evacuate, and that all

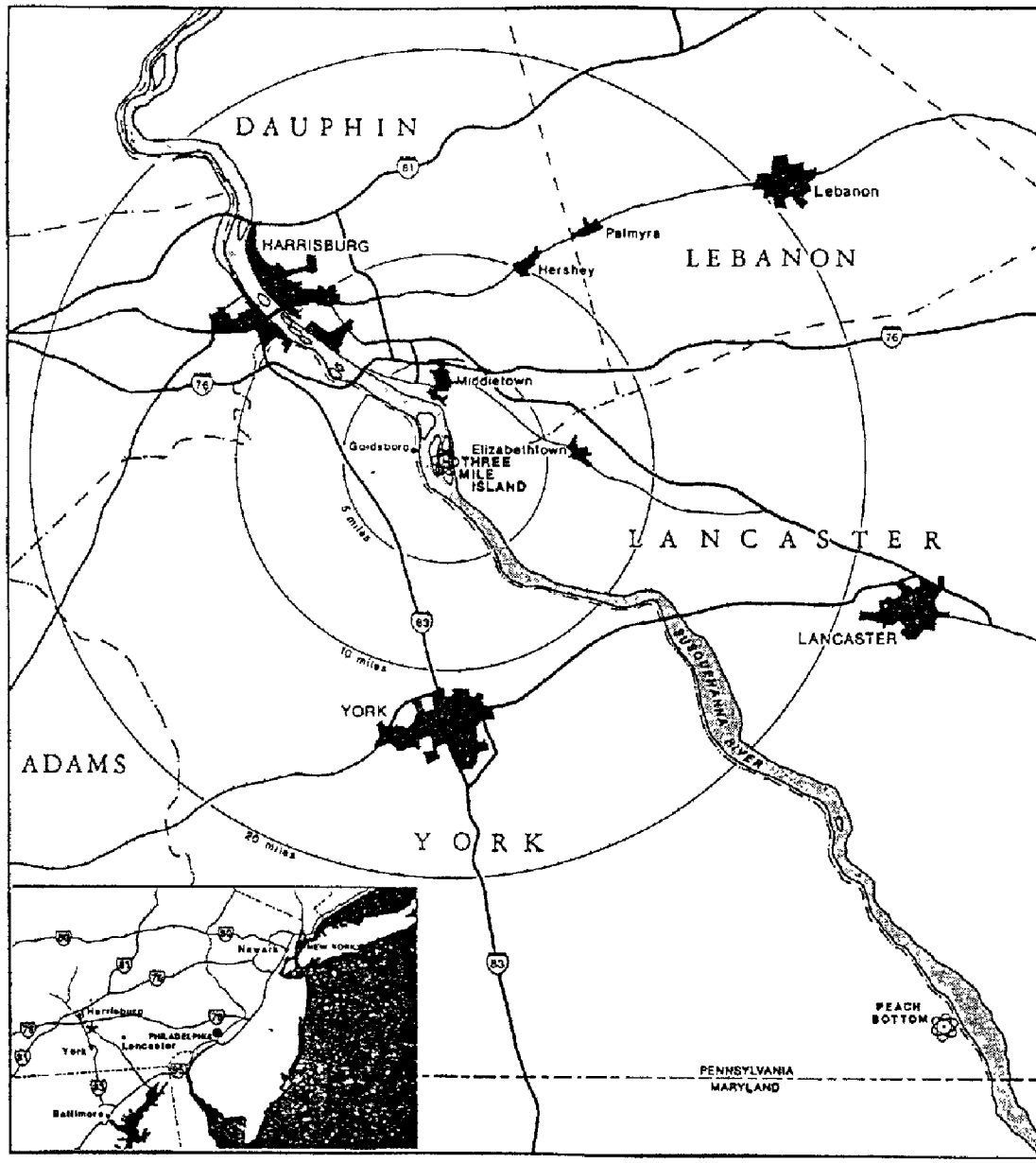

Fig. 1.

residents within 10 miles remain inside with doors and windows closed.

Most evacuated families stayed with friends or relatives (74%), although a significant minority (20%) moved to second homes, commercial accomodations, and other premises. None of our sample respondents used an official evacuation reception center such as the one in Hershey, Pennsylvania (11 miles from TMI). This finding was also confirmed by Brunn, Johnson and Zeigler (1979).

One-third of the evacuees remained in southeastern Pennsylvania, within 10 to 50 miles of the reactor site. Twenty-four per cent of the evacuees elected to remain within their counties of origin. still in the risk zone. They simply moved to places within these counties they considered safe or, more importantly, where they could fin accommodation with friends and relatives. Some serious questions are raised as to whether evacuees remove themselves far enough from danger had a major catastroph occurred.

The majority (53%) of those who evacuated returned home within 1 week of the accident (4th April). A additional 37% returned home 2 weeks later. Three week after the accident, 98% of all evacuees had returned. A few residents took the opportunity for an extended vacation.

The evacuees in our sample were asked in an open-ende question to indicate their specific reasons for evacuatin (Table 1). An overwhelming majority (68%) stated that Governor Thornburgh's advisory was a major factor in their

decision to depart. Twenty-one per cent of this group lived outside the 5-mile radius and only 28% of all evacuating families reported preschool-aged children, the two target groups of the advisory statement. Approximately 46% of the sample cited anticipated consequences, such as harm to children and family, or the possibility of a core meltdown, as reasons for their departures.

EMERGENCY RESPONSE PLANNING

Responsibility for the welfare of residents during any emergency situation rests first with local officials. At the time of the accident, no community within 5 miles of the Three Mile Island plant had emergency response plans approved by the Nuclear Regulatory Commission (NRC), although communities within this radius of nuclear reactors are expected to have such plans (U.S. NRC and USEPA, 1978; U.S. GAO, 1979). The operating utility (Metropolitan Edison) had emergency plans for on-site releases of radioactivity as part of their requirements for licensing, although the utility and surrounding communities had no coordinated response plan for off-site releases. The communications link was poorly designed and only able to handle normal operations. With the exception of a direct link to the Pennsylvania Emergency Management Agency (PEMA) and the State Police, the off-site communication was through a manual switchboard, which, when unattended, could only handle one incoming call at a time (Dynes *et al.*, 1979). This effectively prohibited access to the plant for verification of information by local and county officials who had to rely on the NRC, the state and the news media for information.

The only county plans in existence prior to the accident were for Dauphin County, in which the reactor is located, and that was because of NRC licensing requirements. The plan consisted of emergency evacuation procedures for a 5-mile zone around the reactor. The NRC requirements at the time were only a 2.2 mile radius, defined as the low population zone. The PEMA's function was to integrate local and county plans into an overall state plan and to oversee their implementation.

Six risk counties — Dauphin, Cumberland, Lancaster, Leganon, Perry, York — were designated by PEMA. All or part of the risk county lies within a 20-mile radius of TMI. Host counties were also designated to accommodate potential evacuees. The selection of host counties was based on direction from risk area, size of population centers, and number of major transportation arteries out of the risk area. Distance, other than outside the 20-mile radius, was not a factor (Crowe, Hetz and Emerich, 1979).

The NRC, as part of their general operating procedures, concurred with the utility's on-site plan despite the lack of detailed procedures. The NRC did not undertake a formal review of the plan and did not examine the links between the response plans of the utility and local communities. Existing plans thus were poorly conceived and lacked coordination and integration needed for managing any emergency that would transcend local, county, or state jurisdictions (Dynes *et al.*, 1979). This lack of coordination may have contributed to the confusion at the time of the accident; it most certainly contributed to the ambiguity of the information sent to residents.

ESTIMATED EVACUEES

Several other evacuation studies were done at Three Mile Island (Zeigler, Brunn and Johnson, 1981; Brunn, Johnson and Zeigler, 1979; Flynn, 1979). Over half of the impacted population in the 20-mile radius remained in the area. Approximately 663,500 people (1975 population estimates) were at risk within 20 miles of TMI. Estimates of the number of evacuees range from 76,000 people within 10 miles of the plant, to 144,000 within 15 miles, and 195,000 within 20 miles (Cutter *et al.*, 1979; Flynn, 1979). Not all evacuees left at the first mention of threat (Wednesday, 28th March 1979); many tried to confirm the seriousness of the situation and the potential, personal impact. Most evacuees left as family units and sought temporary accommodation with friends or relatives.

CONFUSION AND UNCERTAINTY

Confusion and uncertainty concerning events at the plant and the degree of risk involved were stated by 41% of our respondents as grounds for evacuation (Table 1). Lack of leadership on the part of elected officials and Metropolitan Edison (the operating utility) and conflicting information were interpreted by 21% of the sample as cues to leave the area.

Two-thirds of our respondents did not evacuate. More than half of those who stayed did so primarily because they felt the danger was not great enough to warrant an evacuation. Fourteen per cent cited fear of looting as a reason for not leaving. Although looting is rare during natural disasters, it is a common misconception of behavioral responses (Dynes, 1974). Looting was insignificant during the TMI crisis partly because the area was not completely emptied. Other reasons for not leaving were: waiting for an evacuation order (8%); job constraints (7%); lack of money (6%); no place to go (3%).

Table 1. Reasons cited for voluntary evacuation*

Reason	No.	Percentage
Thornburgh's evacuation advisory	80	68
Anticipated consequences:	70	60
Safety of children		18
Possibility of meltdown		12
Fear and anxiety		13
Long-term health effects		7
Confusion:	57	41
Lack of leadership and conflicting information		21
Uncertainty		11
Anticipation of evacuation		8
Peer pressure to evacuate	13	9

Total number of households evacuated = 140.
*Multiple responses were possible.

The remaining residents did undertake some precautionary measures either to minimize their risk of exposure to radioactive contamination or to begin preparations to evacuate. These actions included: staying indoors (18%); packing suitcases (15%); filling automobile gas tanks (4%); and waiting for formal evacuation announcements (8%).

Confusion and uncertainty were listed as reasons for evacuating and for remaining in place. Ambiguity by itself does not necessarily lead to a cognition of threat, but ambiguity has been shown to permit extreme latitude for individual interpretations of situations that are based on an individual's own psychological structure (Lazarus, 1966). Ambiguous information such as "the situation is under control, however, please be prepared to leave the area if you hear a siren," contributed to an already confused understanding of what was happening at the reactor site.

Conditions at the reactor site were unclear and the options that officials could take were not clearly defined. Scientists and policy makers were divided on the issue and on the appropriate courses of action. Residents also were confused by the extension of the evacuation planning radius and by some of the preparatory actions taken by county and state officials.

Statements issued by the utility were generally optimistic, conflicting with the messages issued by the NRC. It was not until Sunday, 1st April (day 5 of the crisis), that Governor Thornburgh designated the NRC as the sole source of technical information concerning the status of the reactor. Until that time conflicting reports were issued. Information was sent from the utility to the NRC, to state and PEMA officials, to county and local officials, and then to residents. Sizeable gaps existed in the linear flow of information and, in some instances, information from the state took days to reach local officials. The mayor of Royalton, a borough within 2 miles of the plant never received official notification of the accident (The Harrisburg Evening News, 1979a); while the Mayor of Middletown said he kept informed by listening to radio and television because no information was coming from the plant operators (The York Sunday News, 1979). Local and county officials had to depend totally on the state and the news media for direction.

The weakest link in emergency preparedness and response is the public (Mileti, 1975). Events at TMI support this. One of the main objectives of elected officials was to control panic, although disaster researchers have noted that panic during crises is rare and is a popular misconception about disaster behavior (Dynes, 1974; Quarantelli and Taylor, 1977). There was no evidence of widespread panic on the part of TMI-area residents (Crowe, Hetz and Emerich, 1979). There was no single spokesperson or agency issuing information to the public, and there is some disagreement as to whose function this should have been. PEMA personnel felt it was the job of the Governor's press secretary. The press secretary had other views: "The Governor was the one voice for decisions that impacted on the population. It wasn't me who was designated to be the single voice (The Harrisburg Bulletin, 1979)." Residents were forced to rely on second- and third-hand information (Sandman and Paden, 1979).

Extension of the emergency evacuation zone from 5 to 20 miles also contributed to the confusion. Emergency management officials had been assured by the NRC that their 5-mile plans were sufficient, but on Friday morning, 30th March (day 3), the NRC told state and local officials to extend the radius to 10 miles; later they ordered the zone extended to 20 miles from the plant (Crowe, Hetz and Emerich, 1979). Within hours the number of potential evacuees rose from 27,000 to 700,000, and this caught emergency management officials without satisfactory emergency response plans.

All of the at-risk counties, excluding Dauphin, elected to accommodate most potential evacuees within their own boundaries, but outside of the 20 mile radius of TMI. These counties all had facilities and population centres to support mass-care requirements. Any possible overflow of people would go to adjacent counties in Pennsylvania and Maryland. Dauphin was not so fortunate and was forced to seek emergency accommodation for its residents outside the county. Details concerning these arrangements, including evacuation routes and mass-care sites, were announced to the public over the weekend (30th March — 1st April). News reports on the actions of hospitals and other institutions may have aggravated the situation. Reports of emergency admissions and release of noncritical patients emphasized the potential need to evacuate hospitals in order to provide emergency care for potential victims.

Governor Thornburgh ordered the closing of 23 schools within 5 miles of the plant for an unspecified length of time, effective 12:30 pm, Friday 30th March. Late Sunday night, he recommended that only those schools within the 5-mile radius remain closed and encouraged school districts beyond this radius to open. The decision to open or close schools outside the 5-mile radius was left to local school boards. Owing to the uncertainty of the situation, in light of Thornburgh's statements, risk county schools (beyond the 5-mile radius) remained closed on Monday. Local planning officials were "troubled by the pressure on schools to open, arguing the step would encourage families to return and also tie up buses that would be needed in the event of an evacuation (The Harrisburg Evening News, 1979b)."

Anticipation of an evacuation order and the perceived ensuing problems (traffic jams, money runs on banks, lines at gas stations) were cited by almost 8% of the evacuees as reasons for leaving the area. This finding is consistent with the behavior observed by Janis (1962) and with McGrath's views on psychological stress (1970).

SPATIAL PROXIMITY

It is expected that as distance from the hazard source increases, residents will be less likely to evacuate voluntarily. There is significant association between evacuation and zonation outward from the plant (Table 2). The proportion of those respondents who evacuated decreases with distance, from approximately 47% in the 5-mile zone to 12% outside the 20-mile radius. The impact of Governor Thornburgh's advisory statement is clearly visible in the sharp break in the percentages within a 10-mile radius and those beyond this line. This advisory may have reassured

Table 2. Origin of evacuees by zones from TMI*

Zone		No. of evacuated households	Percentage of total in zone
I	0—5 miles	37	46.8
II	5—10 miles	42	45.2
III	10—15 miles	18	27.3
IV	15—20 miles	17	23.3
V	20 miles	6	12.2

Chi squared = 26.33, d.f. = 4, significance = 0.00, gamma= —0.3599.
*Only considers 120 households who evacuated.

Table 3. Age characteristics of sample evacuees

Age groups in years	No. in sample	No. of evacuees	Evacuees as % of age group
20—29	47	22	46.8
30—39	92	40	43.5
40—49	75	34	45.3
50—59	70	10	14.3
60 and over	65	9	13.8
Unknown	10	5	—
Totals	359	120	

Chi squared = 35.70, d.f. = 4, significance = 0.00, gamma= —0.4124.

some residents as to their relative safety, but it may have decreased the confidence of others, especially those within 11 miles of the plant. It also may have increased stress by making the likelihood of disaster seem more imminent.

Distance from the origin of a nuclear hazard can be viewed as a buffer protecting the individual from immediate and possibly long-term, harm. It functions as an environmental counterharm resource (Lazarus, 1966). Although persons close to the site might have been expected to show a more pronounced response by evacuating to a greater distance, this did not happen. Evacuees living near the site traveled shorter distances than those who lived further away. The mean distance of evacuation was 111.6 miles. One reason may be that there are few accomodations for evacuees beyond the 20-mile radius of TMI because of the rural nature of the area. One would have to travel greater distances (30 miles or more for example) to find sizeable population centers in this zone. Another reason may be a greater cognition of threat on the part of those evacuees further from TMI. Those who evacuated were self-selected respondents who might have represented the most frightened group; hence, they would try to get as far away as possible. Diggory (1956) found that individuals living further from the hazard zone were more apt to overestimate the extent of the threat than those living closer to the high risk area.

SOCIAL CHARACTERISTICS

The third hypothesized influence on evacuation behavior is the social position of the household. Younger households in their child bearing years would be more likely to evacuate than older households with no children present. Size of the household might also be a consideration as the decision to leave is usually a family one and not solely up to one individual. Also, the household's ability or willingness to undertake a voluntary evacuation may also be influenced by social class (occupation, education).

Age

The proportion of those evacuated decreases with age (Table 3). Forty-five per cent of the respondents aged 20—49 evacuated, while only 14% of those over age 50 left the area. Even proximity (5-mile zone) to the hazard could not overcome inertia among the older population.

This was not entirely unexpected. At the time of the crisis, information was conveyed to residents that the high-risk age groups were young children and pregnant women. The presence of preschool-aged children was a strong factor in the decision to evacuate. Seventy households in our sample had preschool-aged children; 40 of them (57%) evacuated.

The consequences of exposure to the other age groups was never explained effectively. There was a lack of agreement among the experts as to the risks involved. Many of our older respondents expressed a lack of concern for themselves, but were relieved that their children and grandchildren left the area. The prevailing attitude among the middle-aged and elderly nonevacuees can best be summed up by one respondent who wrote: "In 20 years, I'll be dead anyway, so why worry?"

Older persons often are reluctant or unable to respond to the possibility of evacuation (Friedsam, 1962; Kilijanek and Drabek, 1979). Several factors may account for this, including the inability of the elderly to leave home in response to warnings because of infirmity or because they did not receive the warning information, a desire not to be separated from familiar surroundings, a fear of a loss of independence and/or being separated from remaining friends and relatives, and the perceived futility of evacuation at their ages. Subjective losses in a disaster are more acute for the elderly, particularly the loss of various symbolic objects, including the home itself. Despite the unknown degree of risk, the elderly may find a greater sense of security at home rather than with relatives or friends or at an emergency center. This may well contribute to inertia concerning evacuation.

We hypothesized that age would influence early knowledge of the accident, but crosstabulation of the data failed to find any noteworthy association between age and early warning or knowledge of the Three Mile Island accident. This may not be the case for the elderly individuals in the sample. Comparison of evacuees and nonevacuees over age 65 (n = 34) with those under 65 (n = 325) indicates that the elderly may have been less likely to have early knowledge of the accident. Sixty-two per cent of those respondents under 65 years of age first learned of the

accident on Wednesday, 28th March, while only 47% of the respondents over age 65 heard about the accident on that day. This difference is statistically significant ($P = 0.016$). An additional 29% of those over age 65 learned on Thursday, while another 21% learned on Friday.

Several factors may account for the lag between the time elderly respondents heard of the accident and when others heard. Homebound elderly people have limited daily interaction with neighbors, friends, and family. The retired or semi-retired have little or no access to information from coworkers. Both of these are important factors determining early knowledge of an emergency. Eighteen per cent of our respondents indicated that their first source of information was neighbors, family, friends, and coworkers (Barnes *et al.*, 1979). The validity of making inferences from these percentages to the general population is questionable, yet the elderly were the only age group in which less than half of the total number of respondents reported learning of the accident on Wednesday, the first day of the crisis.

Household size

Previous researchers have found that families evacuate as units and remain together even if disagreement exists as to whether evacuation is the proper course of action (Moore *et al.*, 1963; Drabek, 1969). Voluntary evacuation from TMI during the crisis appears to confirm this thesis. Eighty-four per cent of the sampled households with evacuees reported complete evacuation. Those individuals remaining generally did so because of job constraints, fear of looting of personal property, or the need to care for livestock.

The number of individuals living in a household was crosstabulated with evacuation behavior. A significant direct association was revealed (chi squared = 9.23, d.f. = 3, significance = 0.050, gamma = 0.2942, $n = 350$). When distance from TMI is controlled, associations between household size and evacuation become insignificant beyond the 5-mile radius. Respondents living within 5 miles of the plant were a little more prone to evacuate if there were more persons residing in the household, particularly if preschool-aged children were present (chi squared = 11.28, d.f. = 3, significance = 0.025, gamma = 0.3156, $n = 101$).

Individuals living alone ($n = 23$) tended to remain in place regardless of age or proximity to TMI. Only 21% of these individuals reported that they evacuated. Age was a major factor influencing evacuation in households with two or more persons. There was also an association between evacuation and education of respondents in households of three to five persons (chi squared = 8.55, d.f. = 3, significance = 0.050, gamma = 0.2772, $n = 187$). Households of this size, where one or two members were preschool-aged children, with a well-educated household head between 30 and 39 years of age, were the most likely evacuees. No associations were revealed when controlling for smaller and larger households. This suggests that larger families were unlikely to have undertaken a complete household evacuation beyond a 5-mile radius of TMI regardless of the respondent's education level.

Although households with two members ($n = 115$) were more apt to leave than individuals living alone, only 26% of these households reported one or both members evacuating. Forty-one per cent of those households with three or more members ($n = 212$) reported that some or all members left. Interaction between other members of the household appears to be an important factor influencing evacuation.

Social class

The influence of social class on evacuation was examined using occupation and education as indicators. No significant association was discerned between the occupation of the head of household and evacuation (chi squared = 6.53, d.f. = 3, significance = 0.089, gamma = 0.1496). Even when controlling for age, education, and zone, no relationship was noted. Education levels of the respondents were weakly associated with evacuation behavior — the more educated the individual, the greater the propensity for that individual to undertake evacuation (Table 4). There was no difference between median years of education for the nonevacuees and evacuees (12.2 and 12.4 years, respectively). When controlling for age, differences in education do not account for differences in adaptive behavior. This is consistent with some of the previous research concerning education and evacuation. Mack and Baker (1961) found that individuals with high school educations were more apt to evacuate than persons with more or less education. Lachman, Tatsuoka and Bonk (1961), however, found no association between education and pre-impact evacuation.

Table 4. Education and evacuation

Years of education	No. in sample	No. of evacuees	Evacuees as % of education group
Less than high school (<12)	49	9	18.4
High school (12)	164	55	33.5
Some collage (13 to 15)	49	13	26.5
College (16+)	82	40	48.7
Totals	344	117	

Chi squared = 14.56, d.f. = 3, significance = 0.005, gamma = 0.2779.

Controlling for proximity to the nuclear power plant clarifies the relationship between education and evacuation (Table 5). The association is spatially inconsistent. Evacuation is strongly associated with education in the 5—10 and 15—20 mile zones. This is not the case in the 0—5 or 10—15 mile zones. The intensity of the threat was greatest in the 0—5 mile zone and residents here tended to evacuate regardless of educational background. Proximity to the hazard and the spacial dimension of Thornburgh's prompt were sufficient to overcome any inertia on the part of most residents to leave. This suggests that proximity to hazard and warnings were the most important prompting factors in the immediate impact zone.

There was no association between education and evacuation in the 10—15 mile zone. Several factors may

Table 5. Summary statistics of education and evacuation behavior by zones

Zone	χ^2	d.f.	Significance	Gamma
I 0—5 miles	1.52	3	0.750	+0.1374
II 5—10 miles	13.72	3	0.003	+0.5820
III 10—15 miles	3.27	3	0.351	+0.0330
IV 15—20 miles	11.54	3	0.010	+0.6470

account for this phenomenon. The major urban centers of Harrisburg and York, and their immediate suburbs are located in this zone, and the majority of the zone's population live in these cities. It has been suggested that urbanism is a significant factor in assessing hazard warnings (Mack and Baker, 1961). Urbanism would influence individuals' assessments of their ability to cope with the act of evacuating, e.g traffic jams, route specifications. There is also a greater exposure to the actions of local officials and neighbors, and to the news media. People were encouraged (or at least were not discouraged) to leave the area. The headlines of the 1st April 1979 Harrisburg Sunday Patriot-News read, "Those Uncomfortable Urged to Leave." Once again, people tended to evacuate from this zone regardless of educational background.

In the 5—10 and 15—20 mile zones, differences in education were important social characteristics discriminating evacuees from nonevacuees. The former zone constitutes a transition between the zone of immediate impact and that of urban influences; the latter was the outermost zone being considered for possible evacuation by emergency management officials. It may be that more educated individuals relied less on prompts or cues, and more on their own initiative in undertaking evacuation.

SOCIAL INFLUENCE

Evidence of increased social conformity in intensified fear settings has been noted (Darley, 1966). We hypothesized that social influence prompted evacuation. Social influence refers to the impact of the responses of friends, neighbors, and others upon individual behavior. Reasons cited for voluntary evacuation from TMI (Table 1) indicate that fear and confusion were pervasive among evacuees and may have contributed to a heightened susceptibility to social influence.

Respondents were asked whether their neighbors left the area during the TMI crisis. The crosstabulation of evacuation and neighbors' behavior (Table 6) suggests a significant association between the respondent's behavior and the reported behavior of neighbors. Individuals evacuating the area reported others undertaking the same behavior (74%). For the nonevacuees, 50% reported that their neighbors did not leave, while 40% replied that their neighbors did leave. An individual who reported that his neighbors left the area was more likely to have evacuated than one who did not. When controlling for proximity to TMI, this association is significant for all zones.

Table 6. Respondent behavior and reported neighbor behavior

	Total No. respondents	% of non evacuees	% of evacuees
Neighbors stayed	129	50.0	9.7
Neighbors left	184	39.7	74.0
Neighbors' behavior unknown	44	10.3	16.3

Chi squared = 56.83, d.f. = 2, significance = 0.000, Goodman and Kruskal Tau = 0.1592.

Social influence has been observed by researchers investigating individuals' responses to hurricanes (Baker *et al.*, 1976). In addition, predispositions to evacuate in response to hurricane warnings are affected by what the individual believes his or her neighbors think or will do about the situation (Carter, Clark and Leik, 1979). Opinion is divided over the role of social influence in prompting evacuation, and further research is needed (Christensen and Ruch, 1980). The results of this analysis suggest, but do not confirm, that social influence is an important factor in pre-impact evacuation decision making.

SUMMARY

The behavior of Three Mile Island residents serves as a case study highlighting some of the contextual, spatial, and social factors influencing voluntary evacuations from technologically hazardous situations. The inability of residents to confirm hazard information resulted in decision making based on confusion cues and ambiguous information. A sizeable percentage of evacuees left not because there was consistent information on which to base their decisions but because of a lack of such information. The individual interpretation of events at the plant and the actions of institutions resulted in two different responses — evacuation and remaining in place.

Proximity to hazard was found to be related to evacuation. Those residents who lived closer to the plant were more likely to undertake an evacuation than those living further away, regardless of occupational or educational levels. A household's stage in the life cycle also influenced the evacuation decision. Older households were less apt to evacuate that were younger households, especially if those younger households had children. There is also some evidence that social influence enhanced the evacuation decision by reinforcing individual behavior through the actions of friends and neighbors.

Thornburgh's advisory had a contagious or spillover effect. Its impact on evacuation decisions extended beyond those individuals in the recommended 5-mile radius from TMI, and it prompted more than those individuals in the two target groups to leave. This contagion must be considered in emegency situations regarding future technological hazards. Emergency management officials may find themselves having to cope with greater numbers o

evacuees and larger volumes of traffic than otherwise intended or expected, particularly if a selective, rather than a general, advisory or evacuation order is issued.

A number of future research questions arise from this analysis. What is the applicability of the model of responses to a range of technological hazards, not just nuclear power plants? Are there similarities between pre- and post-impact responses regardless of the source of the hazard? How applicable is natural hazard research to the study of technological hazards? Recent events (Love Canal, NY; Seveso, Italy; Mississauga, Ontario; Three Mile Island, PA; natural gas leak in San Francisco) point to the vulnerability of populations to these types of hazards and questions the emergency preparedness to mitigate the adverse impacts of these hazards on the local residents.

It behooves all of us to direct some of our research efforts to these pragmatic concerns, especially the assessment of individual risk from technological hazards; the examination of the nature of technological hazards and their distribution; the range of coping responses that may be undertaken and the emergency planning for such actions; and last, the spatial implications of these coping activities. This line of inquiry represents a growing committment within the social sciences to socially responsive research and is an area within which we can make substantial contributions.

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