The Impact of the Accident at the Three Mile Island On the Behavior and Well-Being of Nuclear Workers

Part I: Perceptions and Evaluations, Behavioral Responses, and Work-Related Attitudes and Feelings

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Abstract: In order to assess the impact of the accident at the Three Mile Island (TMI), telephone interviews were conducted six months later with 324 nuclear workers assigned to TMI and 298 workers assigned to a comparison plant at Peach Bottom (PB). Examination of PB-TMI differences, stratified by supervisory status, revealed the following:

Part I: TMI workers reported greater exposure to radiation at the time of the accident and felt that their health had been thereby endangered. TMI workers experienced more uncertainty and conflict at the time of the accident. Coping responses such as seeing a doctor, taking drugs, and increasing alcohol consumption were quite infrequent. Leaving the area was more common; however, over 40 per cent of TMI workers wished to leave but did not do so because of work obligations. TMI workers reported much lower job satisfaction and much greater uncertainty about their job future. (*Am J Public Health* 1981; 71:472–483.)

Introduction

"On Wednesday, March 28, 1979, 36 seconds after the hour of 4:00 am, several water pumps stopped working in the Unit 2 nuclear power plant on Three Mile Island (TMI), 10 miles southeast of Harrisburg, Pennsylvania. Thus began the accident at Three Mile Island. In the minutes, hours, and days that followed, a series of events—compounded by equipment failures, inappropriate procedures, and human errors and ignorance—escalated into the worst crisis yet experienced by the nation's nuclear power industry."

The foregoing paragraph introduces the Account of the Accident, written by the President's Commission.[1] The chronology of the accident and its aftermath are well described in The Commission's Report. The premature reassurance issued by Lt. Governor William Scranton on Wednesday morning* and the appearance of calm throughout Thursday were but an ironic prelude to the suddenly resurging concern and apprehension evidenced on Friday morning. Governor Richard Thornburgh's two advisories of that day—first, that all persons within 10 miles of the plant stay inside and, later, that all pregnant women and preschool children leave the region within a five mile radius and that all schools therein be closed—served to confirm the reality of the threat even as they failed to provide any useful information about it. With the weekend came the great concern about a potential hydrogen explosion inside the TMI-2 reactor.

The ballooning of the hydrogen bubble was almost a symbolic representation of the amorphous expansion of the fears and apprehension of residents in the area. As in a Pirandello drama, this threat of the hydrogen bubble gave rise to several different and contradictory realities. For the people in the vicinity of TMI, the bubble existed as an expanding threat of explosion. For the Nuclear Regulatory Commission (NRC) experts on the scene, the bubble was already a diminishing danger by Sunday afternoon, a reality not shared with the public. And for the nuclear experts who determined that oxygen generation rate made an explosion unlikely, no matter what the size of the bubble, the reality (absence of a threat) lay in detailed scientific calculations and in attempts to convince the colleagues whose calculations were in error.

The end to threat of the accident at TMI was not sharply defined by any specific events or announcements. On Wednesday, April 4, schools outside the five-mile area reopened and all curfews were lifted. However, the Governor's advisory for within the five-mile area remained; this was not withdrawn officially until April 9. Schools were reopened on the 10th, and on April 11 President Carter announced the formation of a Commission to Investigate the Accident at Three Mile Island.

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*"Everything is under control. There is and was no danger to public health and safety."[1]

Assisting the Commission in its task to determine the impact of the accident was a Public Health and Safety Task Force, dealing with: health physics and dosimetry, radiation health effects, behavioral effects, and public health and epidemiology. On the basis of the report of this task force,[2] the President's Commission concluded that, while the radiation effects on the physical health of individuals will be negligible, "The mental stress to which those living within the vicinity of the Three Mile Island were subjected was quite severe".[1]

It was the overall objective of the Behavioral Effects Task Group, headed by Professor Bruce P. Dohrenwend of Columbia University, to examine the effects of the accident on the mental health, attitudes, and behavioral responses of the general population and the nuclear workers. The present report is concerned specifically with the results of the study of the nuclear workers, which was conducted under the umbrella sponsorship of the Public Health and Safety Task Force and as part of the Behavioral Effects Task Group research activities.

Organization of This Report

Because of the length of this report, the methods, findings and discussion are presented into two parts. In Part I we describe the methods of the study and present major findings concerning comparability of the study samples at TMI and a "control" plant; we describe differences between the two groups that involve: perceptions of exposure to workplace hazards; residual concerns and feelings about the accident; coping responses; community perceptions; sense of powerlessness; job satisfaction; job security; and identification with the Company.

In Part II we continue the presentation of the major results: job tension, self-esteem, and perceived support; affective responses to the accident; prevalence of psychophysiological symptoms; demoralization and its components. Additional analyses are carried out to see how the major results are modified by: a) residential distance to the TMI plant (among TMI workers only), and b) presence of a young child at home. Correlates of evacuation behavior and intercorrelations among major study variables are also described. The concluding comments and references at the end of Part II cover both parts of the report.

Methods

The methods of this study reflect heavily the practical constraints under which the research was carried out. The constraints were chiefly those of time (when data collection could start and when it had to end) and of personnel. We settled on a design which called for a telephone survey to be conducted with the workers at TMI and with workers at a "control" nuclear plant some 40 miles away.

Sample

The sample of workers included all employees on the payroll of the Metropolitan Edison Company who were assigned permanently to the TMI Plant as of March 1, 1979, including bargaining unit employees supervisors, and non-exempt employees.**

Nuclear workers at the Peach Bottom (PB) plant of the Philadelphia Electric Company were chosen as the comparison group. This plant is located about 40 miles from TMI, sufficiently close so that the two study samples were of similar ethnic-social composition, broadly characteristic of this region of Pennsylvania. All employees permanently assigned to Peach Bottom comprised this comparison group.

Names and telephone numbers of eligible employees, obtained from the payroll departments of both companies, were arranged into combined alphabetical lists; order of contact was then determined by a random number system. This procedure was designed to assure the representativeness of those actually interviewed in case time did not permit contacting all of the eligible study subjects. As it turned out, we were able to attempt to reach all of the employees on the two lists, but there was insufficient time to keep attempting a contact until we either obtained an interview or were refused by all. We estimate that at least three or four phone calls were made to each TMI employee and at least two or three to each PB worker.

A total of 324 of 533 TMI workers and 298 of 490 PB workers participated in the study, an identical response rate of 60.8 per cent at each location. The non-respondents include both interview refusals and failures to make a contact by the cutoff date for data collection, because of incorrect numbers, worker being away on vacation, etc. Our records indicate that 51.2 per cent of the 209 TMI non-respondents and 62.0 per cent of the 192 PB non-respondents were failures to make a contact despite at least two to three attempts.***

Toward the end of data collection, a separate small methodological study was conducted with a random subset of 125 workers who until then were classified as non-respondents. Those 58 who were brought into the study under these special effort circumstances (mostly the "no contacts," but also a few "refusals") were found to be broadly representative of the other respondents, both on sociodemographic characteristics as well as the various indicators of impact. We tentatively conclude that our inability to continue attempting to contact the eligible subjects did not seriously influence the representativeness of those who did participate in the study. Data available from the payroll records

**The survey did not cover contractor personnel or company employees who were assigned temporarily to TMI during the accident. Most of these were non-company workers involved in construction; the few company employees assigned temporarily to TMI were not working at any one particular location and were not exposed to differentially hazardous conditions.

***Stated reasons for refusing to be interviewed seemed to fall into several categories: unwillingness to be bothered or to give up the time, with some also indicating readiness to be interviewed on company (work) time; doubts about the value of and/or the need for such a study; fear that information collected might be used in some ways against the respondent or against the company; preference for a face-to-face interview over the telephone interview; resentment of company for giving out names and telephone numbers. Overall, it is difficult to discern a consistent direction of a possible bias due to refusals.

permitted some limited comparisons or respondents with non-respondents. Somewhat higher participation rates were found for supervisors at both locations and for TMI workers living farther away from the TMI plant; no meaningful age or sex differences between respondents and non-respondents were observed.

Interview Procedures

The field work was carried out by trained interviewers employed by Capitol Area Health Research, Inc., and supervised by Raymond L. Goldsteen and Karen Goldsteen, two members of the Behavioral Effects Task Group who were also local residents. Data were collected during a one-hour telephone interview with each participant. Choice of this procedure was based upon a growing body of evidence[3-6] from studies of health and behavior, (including a Pennsylvania study)[7] indicating that telephone interviews can provide information as reliable and valid as that obtained from face-to-face interviews and mailed questionnaires. Under-representation due to exclusion of subjects without telephones was not a problem in the present study since virtually every worker on the plant lists had a phone.

Before being contacted by telephone, each eligible worker received a letter inviting participation. The letter explained the purpose and the general nature of the study, described how the data would be used, guaranteed anonymity of responses, and indicated that an interviewer would be phoning in a few days. The letter emphasized the importance of the study, the cooperation of the companies and, in the case of TMI bargaining unit employees, the support of the union as well. The voluntary nature of participation was stressed.

The interviews were conducted by trained interviewers who used a standard guide for introducing and asking questions and for recording data. The interview schedule was predominantly fully structured with precoded answer alternatives. Random follow-up phone calls were used to verify that respondents had been contacted and to monitor the quality of the telephone interviews. The survey interviews began on August 20, 1979 and terminated at the end of September. The cutoff date was necessary in order to meet the deadline of the Task Force report in which some preliminary resuts could be given to the President's Commission. The starting date was only a month after the first meeting of the Task Force on July 23, 1979.

Information Collected

The unique nature of the TMI accident and the special research circumstances suggested that we should view our study as exploratory and descriptive, rather than a more focused hypothesis-testing effort. Nevertheless, in assembling the interview instrument we drew on two areas of research and theory: the disaster literature and the occupational mental health-organizational behavior literature.

Disaster studies[8-15] have amply documented the impact of disaster situations on symptoms of distress and on psychophysiological functioning, sometimes in large proportions of the affected populations. Hence, these indicators of impact play a prominent part in our interview schedule. However, it must be noted that the psychological dimensions of disasters typically studied—floods, hurricanes, explosions—differ from those of the TMI accident. They usually have a clearcut time course, with a definable period of warning, onset, and ending. Moreover, the nature of the danger and the actual damage are reasonably apparent, and suitable coping and avoidance strategies are, at least to some extent, apparent. In contrast, the nuclear worker had a more difficult task of appraising the danger associated with the TMI accident and determining a proper action. Estimating the reality of exposure to radiation, drawing inferences about possible health consequences, and calculating the probability of an explosion or some other subsequent disaster at the work site, could not be easily carried out on the basis of information made available to him or on his past experience; selecting a coping or avoidance strategy was fraught with conflict (e.g., leaving the area was more likely to be viewed as prudent action for the mother with a preschool child, but for the nuclear worker it carried potential overtones of overreaction or abandoning his obligations at the work site).

The second area of research and theory—occupational health and organizational behavior—is relevant because of the special status of the nuclear workers in this situation. Since the TMI workers were permanent members of the organization which experienced the accident, they had both a psychological and economic stake in its outcome. Moreover, to varying degrees, they were directly involved in the accident and had responsibility for controlling the plant and bringing it to a safe condition. Thus the whole literature on occupational stress, work demands, and hazards in the work place[16-23] served as an additional theoretical framework and source of measures. It might be added that it appeared to us that nuclear workers would find themselves in a particularly difficult situation because of the multiple role demands placed upon them. For example, conflict between married employees' concern about the health and safety of their families (with the resulting need to leave the area) vs the need to stay in the workplace and fulfill the requirements of the work role, seemed particularly worth examining.

Overall, the questionnaire is a composite of scales and measures, validated and used in previous studies, and of newly devised questions and measures, suitable for this study but with no previous history of construct validity. Specific relevant information about the study variables will be introduced as the results are presented and discussed.

Limitations of the Study Design

Disaster research is necessarily opportunistic, quasi-experimental, and after-the-fact. In the terminology of Campbell's and Stanley's classical analysis of research designs,[24] our study falls into the "static-group comparison" category, considered one of the weak research designs.[25] However, the weaknesses are potential and their actual presence depends on the unique circumstances of each study. Prior to presentation and discussion of results, we wish to mention two issues.

This was a one-shot survey, conducted five to six months after the accident; conclusions regarding impact are

tied to this point in time and should be referred to as "impact at six months." Both the recollections of the accident and the subjects' descriptions of their present status might well have been different had the data been collected three months earlier or six months later; short-term effects are missed and delayed long-term effects are not yet detected.

The second issue is that the logic of inferring impact of the accident from differences in outcome variables between TMI and PB workers depends on the assumption that the two groups of nuclear workers are essentially equivalent, except for the exposure of the TMI workers to the accident. In the "static-group comparison" design, the two major potential weaknesses (lack of equivalence) are due to biased selection and biased attrition.[24] In the present case, neither selection nor attrition appear to be serious problems. The major self-selection forces operating presumably involve the process of becoming a nuclear worker, but this is shared by both groups.‡

Otherwise, self-selection factors in disasters are mainly indirect ones, such as those associated with being or not being at the location where the disaster strikes; these could be sometimes substantial, e.g., living in tornado-destroyed trailer park vs in undamaged apartment building. However, in the present study it is difficult to think of processes or variables (other than residential distance) which would select one type of workers into the TMI ranks and another type into PB ranks.‡‡

To be sure, each plant, whether nuclear or otherwise, ultimately comes to represent a unique work setting and this fact does set the limits on strict comparability between any pair of plants. Somewhat different personnel policies, differentially evolving supervisory-staff relationships, different safety practices, different levels of cohesion and morale among the workers—all these and others could be contributing to the uniqueness of each plant.

The second potential weakness is biased attrition following exposure to the accident. However, in this study both groups of eligible subjects are defined from company lists antedating the time of accident, and thus attrition is known and is equivalent to non-response, already discussed under the description of the sample. One special attrition problem in this study was the possibility that some of the no-contact non-respondents among the TMI subjects, but not PB subjects, had permanently left the area because of the accident. This biased attrition would, most likely, attenuate the estimated extent of the impact. Using the evidence of disconnected or "not in service" telephone numbers, we estimate this bias to be negligible (< 1 per cent).

It must be also noted that while PB workers were not "exposed" to the accident, they certainly could have been affected by it, as could have been nuclear workers around the country. Consequently, the present design can only detect the *differential* impact of the accident on TMI vs PB workers. The "*absolute*" effect of the accident, in the sense of a before-after change, cannot be detected since the comparison group of PB workers may no longer indicate what the TMI workers were like before the accident.

Results

In order to present the broad, major findings, we contrast TMI and PB workers, classified by supervisory-non-supervisory status. This latter stratification variable seemed to us inescapable even in a first look at the general impact of the accident, while other possible stratification variables did not seem to contribute nearly as much toward communicating the broad findings. From the organizational behavior literature, it is clear that the supervisory-non-supervisory distinction accounts for the greatest amount of variance in worker and work environment characteristics: status, responsibility, and job demands, union membership, etc.

Description of Study Samples and Their Comparability

Table 1 displays the descriptive data on the study samples, broken down by supervisory status. The following differences are noteworthy: more female workers at TMI; older workers among PB supervisors; greater seniority and higher income of PB workers.

Information supplied to us by the two companies reveals that the Peach Bottom plant is older by several years. In fact, a small prototype unit was completed in 1967 (phased out in 1974) and the two presently operating units began in 1974. This difference would be reflected primarily in the older age and greater seniority of the PB supervisors; possibly, different hiring practices at the start would have also reduced female employment. The income differences largely disappear when one takes into account overall seniority, years on present job, and sex. The subjective economic data reveal the PB and TMI groups to be virtually identical.

The residential data reveal the TMI workers somewhat less likely to be living in a single family dwelling; presumably, the presence of a large city (Harrisburg) near the TMI but not the PB plant makes other alternatives, such as apartments, more available. The data on residential distance to the TMI plant reveal the expected (and necessary) differences between TMI and PB workers. The employment data reveal that virtually everyone was working full-time at the time of interview.‡‡‡

As we proceed with the presentation of results, we shall specifically note any instances in which statistical adjust-

‡Becoming a nuclear worker might involve a self-selection process of accepting a potentially hazardous job and developing diverse defense mechanisms and coping strategies serving to minimize the effects of daily prospects of unexpected crises in the workplace. This could be seen as blunting our efforts to detect the impact of the accident, if nuclear workers in general are indeed "desensitized" by this presumed self-selection process.

‡‡The measured characteristics of the TMI and PB subjects along sociodemographic and work-related dimensions are examined and discussed in the Results section.

‡‡‡This is important since if the accident had precipitated significant lay-offs among the TMI workers, the possible effects of the lay-off would be difficult to separate from the effects of the accident. For the reader who is puzzled that nearly all TMI subjects were working full-time even though the Unit 2 had been shut down, we will simply note that a smoothly functioning nuclear plant demands less work than one shut down by an accident. The lack of a PB-TMI difference on "present family economic situation, compared to six months ago," is reassuring for the same reason.

TABLE 1—Some Descriptive Characteristics of Study Samples

Characteristics		Supervisory PB	Supervisory TMI	Non-Supervisory PB	Non-Supervisory TMI
Participation rate (% target population)		81.4	66.3	52.6	58.3
Number of subjects interviewed*		114	110	181	212
Per cent female subjects		0.9	6.4	3.9	12.3
Per cent married		85.8	87.3	83.4	79.2
Per cent living in single family house		91.2	86.4	82.2	69.8
Mean age		41.5	34.9	32.8	33.4
Mean no. of children (≤18) living at home		1.9	1.8	1.8	1.7
Per cent with child ≤5 at home		19.3	33.6	42.5	26.4
Mean years of schooling		14.3	14.3	13.2	13.0
Mean no. of years lived in (York, Harrisburg) area		14.9	13.4	13.6	19.9
Distance of home from TMI	% ≤ 5 miles	0.0	33.0	0.6	39.3
	% ≥ 50 miles	52.3	0.9	49.7	0.5
Mean no. of years worked at (PB, TMI)		7.85	5.24	4.77	4.15
Years on *present* job	% ≤ 1 year	17.5	22.7	22.7	19.8
Per cent working full-time at interview time		100.0	98.2	98.3	96.2
Mean 1978 income on present job**		29,700	22,600	24,700	19,600
Present family economic situation, compared to 6 months ago (4 items, 1 = worse → 3 = better)	Mean	2.36	2.29	2.33	2.34
	S.D.	0.42	0.42	0.41	0.41
Relative economic deprivation (2 items, 1 = favorable → 5 = unfavorable)	Mean	1.70	1.78	1.81	1.80
	S.D.	0.49	0.51	0.55	0.59

*3 PB and 2 TMI subjects had missing information on supervisory status.
**Approximately 30% of respondents have missing data; the great majority of these had not been in their present job throughout 1978.

ments for the differences illustrated in Table 1 alter the findings.

Perceptions of Environmental Hazards

The data presented in the next two tables come from a section of the interview which dealt with "several possible safety hazards which exist in many work places." The list of 12 safety and health hazards was modified from an instrument previously used in national surveys of working conditions.[23, 26] It included such items as: dangerous chemicals, dangers from fire or shock, dirty or badly maintained work areas, too much noise, dangerous work methods, etc. The subjects first indicated if the job exposed them to these hazards (yes/no); those who answered positively were then asked "how much of a problem was this for you" (from "no problem at all" to "great problem"). The list was administered twice: first, describing "The six months before the TMI incident began on March 28, 1979" and next describing the situation "during the TMI incident (3/28/79-4/11/79)."

Table 2 presents the findings on perceived exposure to radiation hazards. It can be seen that in their descriptions of the pre-accident period, PB and TMI workers are not significantly different; the slight difference indicates fewer reports of problems among TMI workers. Also worth noting is the fact that, in both settings, supervisors perceive less of a problem than non-supervisors. This finding may indicate actual differences in the work environments and/or greater reluctance on the part of supervisors to "perceive" problems which might reflect negatively on the Company.

The middle section of Table 2 shows that in describing the period during the accident, TMI workers now clearly report more problems. The bottom section of the Table reveals that, overall, only about 5 per cent of PB workers saw greater exposure to radiation hazards for the time of the TMI accident than for the previous six months, compared to some 43 per cent for the TMI workers.

The data in Table 3 suggest that the accident did not affect the perception of exposure to other work hazards. The only significant differences are on "risk of catching diseases" where the PB non-supervisory workers report greater hazards for *both* occasions; clearly, this is unrelated to the accident. The bottom of Table 3 reveals that about 45 per cent of the TMI workers saw their health unduly endangered because of the accident. Since this is about the same per cent as that for perceived increase in radiation hazard, and since no other changes in perceptions of work hazards can be attributed to the accident, it is a reasonable conclusion that the perceived greater danger to health is due to radiation alone.

The findings in Tables 2 and 3 were re-examined with an additional stratification on sex. Essentially, the findings were that female employees were less likely to report exposure to various work hazards, presumably, because of their excess in such job categories as "clerical." Female TMI worker concern about radiation exposure for the period after the ac-

TABLE 2—Perceived Exposure to Radiation

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
Did your job ever expose you to . . . radiation?					
During the 6 months before March 28		%	%	%	%
No; yes, but no problem at all		59.5	60.4	41.6	45.9
Yes, slight problem		30.6	34.0	30.1	37.8
Yes, sizable problem		6.3	4.7	16.2	10.0
Yes, great problem		3.6	0.9	12.1	6.2
	gamma	−.05		−.15	
	significance	n.s.		n.s.	
During the TMI incident (3/28-4/11)					
No; yes, but no problem at all		55.8	43.5	45.6	30.1
Yes, slight problem		30.8	29.6	26.9	24.8
Yes, sizable problem		9.6	13.9	17.5	25.2
Yes, great problem		3.8	13.0	10.0	19.9
	gamma	.27		.30	
	significance	$p < .01$		$p < .001$	
Difference in exposure to radiation (derived)					
Time of incident lesser problem		3.8	5.7	7.0	4.9
No difference in exposure		87.5	50.9	89.9	52.5
Time of incident somewhat more problem		7.7	30.2	1.9	25.5
Time of incident considerably more problem		1.0	13.2	1.3	17.2
	gamma	.62		.75	
	significance	$p < .001$		$p < .001$	

*This N may be slightly reduced due to occasional missing data.

cident increased, but the level of concern remained much lower than that of males. We conclude that the slight excess of females at TMI (particularly non-supervisory) tends to attenuate the PB-TMI differences, but because of the small numbers involved, the results for males only are virtually identical to those presented in Tables 2 and 3.

It is of interest that the workers' perceptions of increase in radiation hazard are in broad agreement with the conclusions of the Health Physics and Dosimetry Task Group, which estimated an increase in whole-body dose to TMI workers from about 0.06–0.45 rems for a three month period before the accident to about 1 rem for three months after March 28.[2]

The primary findings in Tables 2 and 3 may also be viewed in a "positive" fashion: over 50 per cent of the TMI workers report, at the time of the interview, no impact of the accident in the sense of no increase in perceived radiation hazards and in their estimate of health endangerment.

Persistence of Concerns

The results in Table 4 address the extent to which the concerns of the TMI workers, heightened by the accident, may have persisted for at least six months, up to the time of the interview. Responses to the first three questions are similar for PB and TMI workers, suggesting that lingering concerns and fears among TMI workers due to the accident can no longer be detected. Table 4 also shows that suspicions about the information released by officials were not unduly concentrated among TMI workers. However, it is worth noting that about 72 per cent of workers at both settings combined expressed at least some doubts about the veracity of the official information released during the time of the accident.

The final item of Table 4 suggests that while the TMI workers are not significantly more optimistic about the possibility of something good resulting from the accident, they do give a different set of reasons for thinking that way. Specifically, they give somewhat more responses indicative of a personal or family impact. These results are reminiscent of anecdotal evidence about experiences which represent a "close brush with death."

We realize that Table 4 cannot possibly tell the story of "residual" concerns. Frequent news headlines about the aftermath of the accident, such as the story of the cleanup and the planned release of Krypton, suggest that the impact of the accident may ebb and flow, but has not ended. For this reason, the continued surveillance of the community residents and the nuclear workers, conducted by other investigators, [27, 28] is most important.

Conflict, Uncertainty, and Some Responses to the Accident

In Table 5 we have assembled data which bear on the issue of uncertainty and conflict reported by the workers. It can be seen, first of all, that TMI workers were somewhat less likely to feel that they were kept fully informed by their employer about health dangers in the workplace; the dif-

TABLE 3—Perceived Exposure to Other Hazards

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
Did your job ever expose you to . . . risk of catching diseases?					
During the 6 months before March 28	Mean**	1.13	1.11	1.31	1.07
	Significance	n.s.		$p < .001$	
During the TMI incident (3/28-4/11)	Mean**	1.15	1.06	1.26	1.14
	Significance	n.s.		$p < .05$	
Did your job ever expose you to . . . dangerous work methods?					
During the 6 months before March 28	Mean**	1.11	1.09	1.29	1.29
	Significance	n.s.		n.s.	
During the TMI incident (3/28-4/11)	Mean**	1.10	1.20	1.25	1.36
	Significance	n.s.		n.s.	
Did your job ever expose you to . . . [a standard list of 10 hazards such as noise, dangerous chemicals, air pollution, dirt, etc.]?					
During the 6 months before March 28	Mean**	1.28	1.21	1.49	1.48
	Significance	n.s.		n.s.	
During the TMI incident (3/28-4/11)	Mean**	1.26	1.19	1.44	1.36
	Significance	n.s.		n.s.	
Do you feel that your health was endangered more than usual during the TMI incident due to hazards in the workplace?	% Yes	2.8	38.0	6.1	49.0
	Significance	$p < .001$		$p < .001$	

*This N may be slightly reduced due to occasional missing data.
**Based on a 3 point scale: 1 = No exposure or no problem at all
2 = slight problem
3 = sizable or great problem

ference between TMI and PB is significant when the supervisory and non-supervisory groups are combined. Regarding expectations about immediate outcomes of the accident, it is apparent that TMI workers were about twice as likely as PB workers to recall that they "didn't know" what to expect. Interestingly, PB workers had more definite expectations about outcome in either direction: more likely to list some specific serious outcome as well as to expect the accident to pass without any notable consequences.

The remainder of Table 5 clearly reveals the greater conflict experienced and recalled by TMI workers: their felt need to be in different places at the same time, the intrusion of work demands on their overall planning of how to react to the accident, and the specific conflict with spouse over arriving at an agreed-upon decision regarding the family's response to the accident. Additional open-ended questions revealed that for non-supervisory TMI workers, the overwhelming majority (about 90 per cent) of instances of conflict involved the work role vs the family role; for the TMI supervisors, some 25 per cent of instances of conflict involved two or more different aspects of their work role demands.

The findings presented in Table 5 were recomputed for male employees only and the results were found to be altered only very minimally. This is both because of the small numbers of female subjects and because their answers tended to replicate the PB-TMI differences for men.

In Table 6 we present findings on selected responses to the accident which might be broadly characterized as coping reactions. It can be seen that TMI workers were somewhat more likely to visit a doctor specifically because of the accident, and to take more drugs and drink more alcoholic beverages because of felt distress or tension associated with the accident; for the non-supervisory workers, the TMI-PB differences are significant or nearly so. It is also evident that these three kinds of reactions are quite infrequent and apparently do not represent the preferred coping styles of an important minority of workers.*

*We are not fully comfortable with our assessment procedures here. The subjects had to specifically admit and acknowledge that the behavior asked about was a conscious and intended reaction to the accident. Possibly, this is a too restrictive way of asking about such behavior. On the other hand, simply asking about doctor visits or alcohol consumption for a specified period seemed to us a too imprecise way of getting at the accident-related responses.

TABLE 4—Residual Concerns and Feelings

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
Are you satisfied that you are now *safe* and not contaminated by radiation?	% Yes	99.0	96.0	89.2	82.4
	Significance	n.s.		n.s.	
At present, how often do you *fear* living near [TMI, PB]?	% Never	91.5	93.0	90.1	84.2
	Significance	n.s.		n.s.	
Has the TMI incident made you more concerned about the health of any of your children (Ss with children only)?	N	77	78	127	133
	% No	89.6	91.0	79.5	79.7
	Significance	n.s.		n.s.	
Do you feel that the information you were getting from state and federal officials during the TMI incident was truthful?	% Yes	35.7	27.8	30.7	21.9
	% Maybe, don't know	28.6	33.3	21.6	27.6
	% No	35.7	38.9	47.7	50.5
	gamma	.11		.10	
	Significance	n.s.		n.s.	
Sometimes, *something good* comes from serious incidents such as that at TMI. Do you think anything good has come . . . ?	% Yes	92.9	95.3	86.7	91.8
	Significance	n.s.		n.s.	
If "yes", what good do you think came from the incident?	N	106	104	155	188
	% Giving self- or family-oriented response**	0.9	12.5	3.9	13.3
	% Giving "increased safety of nuclear power"	62.3	58.7	63.2	60.6
	% Other reasons	36.8	28.8	32.9	26.1
	Significance (X^2, 2df)	$p < .01$		$p < .01$	

*This N may be slightly reduced due to occasional missing data.
**Includes: increased closeness of family members, formation of new set of values, learned something about oneself.

The remainder of Table 6 deals with leaving the area as the response to the accident. Among the workers themselves, this was not a frequent reaction and only the PB-TMI contrast for non-supervisory workers shows a significant difference. However, if one considers the response of "didn't leave" because "had to work" as equivalent to wanting to leave, then it can be seen that about 50 per cent of TMI workers left the area or wanted to, in contrast to about 10 per cent for PB workers. The data on spouses reveal that some 30 per cent of spouses of TMI workers left; overwhelmingly, these spouses were from families where there were children who also left. It is interesting to note that "having to work" also suppressed the frequency of spouses leaving the area.

The average stay away from the area was 4.1 days for TMI workers and 6.7 days for the spouses of TMI workers. The homes of TMI workers where at least one family member left the area were closer to the TMI plant (7.0 miles) than the homes of TMI workers where no family member left (12.4 miles). At least one parent left in 43 per cent of the TMI worker homes with a child under five years of age and in 16.2 per cent of such homes without a young child. The comparable rates of leaving for PB families were 5.1 per cent and 1.5 per cent respectively.

When the findings in Table 6 are further stratified by sex, the findings for male workers only remain virtually the same as those seen for the total sample. The one exception is the variable concerning taking "drugs to help you get through TMI." Since three of the five TMI non-supervisory workers saying "yes" are women, the difference between PB and TMI non-supervisors, when computed on men only, becomes insignificant (0.0 per cent vs 0.9 per cent).

The reports of the Behavior Effects Task Force of the President's Commission[2] and other sources[29] reveal that about 60 per cent of all community residents in the five mile radius of TMI had at least one household member leaving the area; for the 6-20 mile radius, the per cent is somewhat lower, 48 per cent. The respondents within the total 20-mile radius who had a preschool child at home left at the rate of 77

TABLE 5—Some Elements of Uncertainty and Conflict Surrounding the Accident

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
During the TMI incident do you think your employer kept you *fully informed* about any dangers or unhealthful conditions you may have been exposed to on your job?	% No	12.0	20.0	22.2	31.0
	Significance	n.s.		n.s.	
What did you expect might happen when the accident first occurred?	% Didn't know	20.6	40.2	22.1	39.4
	% Expected nothing to happen	54.6	37.8	45.0	40.6
	% Giving some expected outcome**	24.7	22.0	32.9	20.0
	Significance (X^2, 2df)	$p < .05$		$p < .01$	
During the TMI incident did you ever feel the need to be at more than one place at the same time?	% Yes	7.0	37.6	12.4	35.8
	Significance	$p < .001$		$p < .001$	
How strongly did you feel the need (0 = No to above 10 = very great need)?	Mean	0.60	2.65	0.83	2.64
	Significance	$p < .001$		$p < .001$	
To what degree were your decisions about what to do during this period affected by your feelings of responsibility to report for work (1 = very low 10 = very high)?	Mean	6.19	8.01	5.99	7.72
	Significance	$p < .001$		$p < .001$	
Did you and your spouse have conflict while you were reaching decision during the TMI event (married Ss only)?	N	91	89	137	162
	% Yes	5.5	15.7	9.5	19.1
	Significance	$p < .05$		$p < .05$	
If you had not been employed in your current job, would you have done anything different during the TMI incident?	% Yes	24.1	32.4	19.5	37.2
	% Don't know	14.8	19.4	14.4	17.4
	% No	61.1	48.1	66.1	45.4
	gamma	.22		.38	
	Significance	n.s.		$p < .001$	

*This N may be slightly reduced due to occasional missing data.
**Expected outcomes mentioned include: shutdown, plant damage, meltdown, blow-up, radiation leakage.

per cent. Overall, it is rather clear that the TMI workers and their families were considerably less inclined to leave the area during the accident than were community residents from the same area; this is true for both those with and without a pre-school child at home.

Community Perceptions

Table 7 presents the findings for a selected set of variables which deal with perceptions of how the accident might have been seen by community residents. The answers to the first question reveal that nuclear workers at both sites believed that their friends and relatives were more concerned about the accident than they themselves were. The PB-TMI differences suggest that TMI workers were less likely to see themselves agreeing with their friends and relatives regarding the amount of concern over the accident and more likely to feel a discrepancy, in either direction, in their level of concern compared to friends and relatives. When the data are pooled across the supervisory and non-supervisory levels, the PB-TMI difference is significant ($X^2 = 8.26$, $p < .02$).

The next three questions in Table 7 try to get at the workers' estimates of how the community might have seen the nuclear workers' performance during the accident. The PB-TMI differences in the answers suggest an interesting pattern: while the PB and TMI workers do not differ significantly in their estimates of how the community evaluated and appreciated the performance of nuclear workers, the TMI workers are significantly more likely to feel that the

TABLE 6—Some Responses to the Accident

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
Have you contacted a doctor because of what happened at TMI?	% Yes	0.9	5.5	0.6	7.5
	Significance (Fisher's exact test)	p = .053		p < .001	
During the TMI incident did you take any drugs? Did you take these drugs to help you get through TMI?	% Yes to both	0.9	0.9	0.0	2.4
	Significance (Fisher's exact test)	n.s.		p = .045	
During the TMI incident did you drink any alcoholic beverages? Did you drink these . . . to help you through TMI?	% Yes to both	0.9	1.9	1.1	3.4
	Significance (Fisher's exact test)	n.s.		n.s.	
Did you leave [the area] at any time during the incident (3/28–4/11)?	% Yes	4.9	3.7	5.0	10.8
	Significance (Fisher's exact test)	n.s.		p < .05	
Why didn't you leave (among those who didn't leave)?	N	98	105	153	189
	% responding "had to work"	5.1	45.7	8.5	38.6
	Significance	p < .001		p < .001	
Did your spouse leave [the area] at any time . . . (for married Ss only)?	N	86	94	128	170
	% Yes	4.7	29.8	4.7	30.6
	Significance	p < .001		p < .001	
Why didn't (s)he leave (among married Ss whose spouse didn't leave)?	N	82	66	122	118
	% responding "had to work"	3.7	31.8	2.5	23.7
	Significance	p < .001		p < .001	
Did your children leave [the area] at any time . . . (for Ss with children only)?	N	66	77	109	132
	% Yes	3.0	33.8	5.5	38.6
	Significance	p < .001		p < .001	

*This N may be slightly reduced due to occasional missing data.

community's view is less justified. In other words, PB and TMI workers agree in their assessment of community perceptions but disagree somewhat on how justified such perceptions are. As in the first question in Table 7, the TMI workers see a greater gap between how they see the accident and how (they think) the community sees it.

The last variable examined in Table 7 is labeled powerlessness; the items come from the Political Efficacy Scale[30, 31] and the scale is intended to measure a segment of the broader concept of alienation.[32] The general notion being examined here is that crisis situations, such as the TMI accident, in which the individual has little power to influence the outcome and is dependent on various governmental bureaucracies for information and guidance, may increase one's sense of powerlessness. The findings in Table 7 do not provide support for this hypothesis, since the differences between PB and TMI on powerlessness are not significant. Of course, two other possible interpretations are also tenable: the accident increased the sense of powerlessness *both* at PB and TMI; the accident had an effect at TMI, which lasted less than six months.

Additional analyses of Table 7 results by sex of respondent do not alter the findings in any meaningful way.

Work-Related Attitudes

The data in Table 8 examine the impact of the accident on several traditional indicators in the organizational psychology literature. The first item is a brief job satisfaction

TABLE 7—Perceiving Community Perceptions and Sense of Powerlessness

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
How would you rate the concern of friends and relatives *outside* of this area about the TMI incident?	% more concerned than you	66.0	70.3	66.5	71.8
	% about the same amount of concern as you	28.0	18.8	26.6	17.6
	% less concerned than you	6.0	10.9	7.0	10.6
	Significance (X^2, 2df)	n.s.		n.s.	
How do you think the *performance* of nuclear workers such as yourself was seen by people in the community during the TMI incident (1 = made serious errors to 10 = performed very capably)?	Mean	4.52	4.60	4.72	4.62
	S.D.	2.62	2.97	2.71	2.66
	Significance	n.s.		n.s.	
To what degree do you feel this view was *justified* (1 = completely unjustified to 10 = completely justified)?	Mean	5.26	4.32	5.73	4.66
	S.D.	3.12	2.97	3.06	3.15
	Significance	$p < .05$		$p < .001$	
How much do you feel the general public *appreciated* the work of nuclear workers such as you during the TMI incident (1 = very little appreciation to 10 = very great appreciation)?	Mean	3.93	3.89	4.16	4.16
	S.D.	2.82	2.75	2.83	2.84
	Significance	n.s.		n.s.	
Powerlessness (4 items: public officials don't care; can't influence actions of the government; can't really understand politics & government; don't have any say about what the government does; 0 = disagree to 2 = agree	Mean	0.88	0.91	1.03	1.11
	S.D.	0.63	0.55	0.67	0.64
	Significance	n.s.		n.s.	

*This N may be slightly reduced due to occasional missing data.

scale which comes from the continuing national surveys of Quality of Employment.[23, 26]** It can be seen that substantial differences in job satisfaction exist at both the supervisory and non-supervisory levels between PB and TMI workers. Since the distribution of scores on this scale is rather skewed, the findings are also presented in terms of per cent of subjects who choose "most satisfied" to all four items; approximately twice as many PB as TMI workers are "most satisfied."

The next scale in Table 8, called Job Future, comes from a national study of 23 occupations[16] and is there referred to as Job Future Ambiguity. It can be seen that again there is a substantial impact of the accident: TMI workers at both supervisory and non-supervisory levels report considerably more uncertainty about their job future than do PB workers. It might be noted that in this PB-TMI comparison, the general impact of the accident on perceived job future in the nuclear industry overall cannot be detected; the comparison only tells us about the greater job uncertainty specific to the TMI plant location and is presumably associated with the issue of cleanup and reopening of the TMI facilities.

**It is referred to as "facet free" because instead of measuring satisfaction with specific aspects of one's job (e.g., pay, supervision, advancement, work content, etc.) it reflects the worker's general affective and evaluative reaction to the job. It is this latter aspect of job satisfaction which ought to be more sensitive to the impact of the accident.

TABLE 8—The Impact of the Accident on Work-Related Attitudes and Feelings

		Supervisory		Non-Supervisory	
		PB	TMI	PB	TMI
	N*	114	110	181	212
Job Satisfaction, "facet free" (4 items about "how you experience your *present job situation*": overall job satisfaction; if you had to decid all over again; job measures up to what you wanted when took it; if friends interested in a job like yours; 1 = least to 5 = most satisfied)	Mean	4.42	4.07	4.15	3.88
	S.D.	0.92	0.92	1.05	1.01
		$p < .005$		$p < .01$	
	% with "perfect" score	56.9	30.1	45.7	24.4
		$p < .001$		$p < .001$	
Job Future (4 items about "how you see the *future of your occupation*": future career picture; opportunity for promotion & advancement; job skills of use & value 5 yrs. from now; your responsibilities in 6 months; 1 = somewhat uncertain to 5 = very certain)	Mean	4.40	3.92	4.35	3.81
	S.D.	0.57	0.80	0.70	0.91
		$p < .001$		$p < .001$	
	% with "perfect" score	26.2	12.0	28.2	8.9
		$p < .01$		$p < .001$	
"Identification" with the Company How do you feel when you hear someone criticizing (PB, TMI) or comparing it unfavorably . . .? 1 = mostly agree with criticism to 5 = gets you quite mad	Mean	3.54	3.80	3.07	3.43
	S.D.	1.12	1.15	1.21	1.24
		$p < .05$		$p < .005$	
How would you feel if someone suggested that (son/daughter) work for the same company?: 1 = strongly disapprove to 5 = completely approve	Mean	4.43	4.19	4.27	3.81
	S.D.	0.96	1.03	1.09	1.27
		$p < .05$		$p < .001$	

*This N may be slightly reduced due to occasional missing data.

The last variable examined in Table 8 reflects the concept of identification with the work organization; the two items come from a longer eight-item scale.[33] In spite of the fact that the two items are thought to tap the same construct and thus should be combined, it is apparent in Table 8 that the impact of the accident was actually a differential one. The TMI workers show a stronger identification with the Company than the PB workers in the sense that they are less willing to agree with or to accept criticisms of their Company. On the other hand, the TMI workers show a weaker identification with the Company in the sense that they are less likely to want to see their son or daughter work for the same company. It is a fair interpretation to suggest that the accident has made the TMI workers more ambivalent about their place of employment.

The data in Table 8 were rerun with an additional stratification on sex. On Job Satisfaction, women workers (particularly non-supervisory) were found to have higher levels of satisfaction in general; the specific PB-TMI differences were greater among females, suggesting a somewhat stronger impact of the accident among them. Job Future was unaffected by sex-specific analyses. On the two items regarding identification with the company, the PB-TMI differences seen in Table 8 were evident both among men and women, with the latter showing a greater difference. This again suggests a somewhat stronger impact of the accident on women workers.

Two of the variables in Table 8 show a more than negligible association with one of the socio-demographic variables on which the PB and TMI groups are not fully comparable (see Table 1). Specifically, among supervisors, age is positively related to Job Satisfaction and Job Future ($r = .21$ for both). Adjusting for the younger age of the TMI supervisors leads to an adjusted mean job satisfaction of 4.19 ($p < .05$ for difference with PB) and an adjusted mean job future of 4.02 (still $p < .001$ for difference with PB). Clearly, then, age differences between PB and TMI workers were inflating the estimated impact of the accident somewhat.