

# Three Mile Island Health Effects Research Program\*

By

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\* Presented at the 56th Pennsylvania Academy of Science Annual Meeting,  
April 20, 1980 held at Seven Springs, Pennsylvania

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Dick Thornburgh, Governor, Commonwealth of Pennsylvania

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## THREE MILE ISLAND HEALTH EFFECTS RESEARCH PROGRAM<sup>1</sup>

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The Three Mile Island nuclear accident of March 28, 1979 has caused a significant impact upon many facets of human life and social structure not only within Pennsylvania, but also elsewhere in the U.S. and abroad. As a mandate of the State Health Department, it became immediately clear that possible health effects of the accident must be evaluated. During the 10-day crisis, it was not possible to ascertain accurate information regarding radioactive emissions from the damaged nuclear reactor into the environment. However, the presence of diffuse and growing psychological disturbance in the area was apparent.

Within a short period of days following the accident the Bureau of Health Research of the Pennsylvania Department of Health was able to conceptualize and develop a comprehensive plan for a variety of epidemiological and other health studies designed to assess the impact of the TMI accident. Specific studies conceived during this critical period reflect mostly the existing epidemiological knowledge regarding biological effect of low level ionizing radiation and of severe emotional stress. The Bureau Director was designated by the Governor of Pennsylvania to coordinate and manage all health-related research activities relative to TMI. At the same time, a special Advisory Panel was commissioned by the Secretary of Health to oversee and guide all TMI-related health studies administered by the Bureau of Health Research. A brief description of each study follows:

### A. *TMI Census:*

One of the first projects initiated after the accident was a *special census of all persons living within five miles of TMI*. After careful examination of the amount of radiation emitted and dispersion factor a distance of a five-mile radius was chosen for the census. The primary purpose of TMI census was to develop a population profile which would provide a basic framework for future studies of morbidity and mortality. In addition to usual demographic data, such as age, sex and race, the census questionnaire included such items as marital status, smoking habits, medical history (particularly

cancer and thyroid disease), recent pregnancy experience, medical and occupational radiation exposure, and detailed whereabouts during the 10-day crisis when abnormal radioactive releases were reported.

A staff of 150 enumerators were hired by the Pennsylvania Department of Health to canvas the TMI area. Other personnel and technical guidance were provided by the U.S. Bureau of the Census and the Center for Disease Control. Sociodemographic analysis and epidemiological observations are now being made of the census results, covering approximately 38,000 individuals in 14,000 households. A series of reports will be forthcoming.

### B. *Pregnancy Outcome Study:*

Both ionizing radiation and severe emotional stress can affect human reproductive process and pregnancy outcome. It is known that the fetus is highly sensitive to such environmental insults. To evaluate possible health impact of the TMI accident, a carefully designed prospective *Study of Pregnancy Outcome* was initiated in August, 1979. This study covers all pregnant women residing within a 10-mile radius of the TMI, who gave births from March 28, 1979 through March 27, 1980. This study cohort consisting of approximately 4,000 deliveries will be compared with a control cohort of another 4,000 deliveries during a one-year period in the same geographic area immediately following the study cohort. The study cohort will also be compared with similar data collected in the same general area during the immediately preceding four-year period. Pregnancy outcome measures being investigated are: fetal death (including 16+ week abortions), neonatal (28 days) death, hebdomadal (one week) death, prematurity (gestation < 37), immaturity (birth weight < 2,500 grams), congenital anomalies, and low Apgar score (< 7).

Although the study design is that of "before-and-after" comparison of cohorts, measures of radiation exposure and psychological stress (expressed in terms of overt statements and stress coping patterns, such as taking tranquilizers and sleeping pills) are also included, which will be related to each of the seven outcome measures described earlier. Since there are many other factors which can influence pregnancy outcomes, all such influences are taken into account; they are — maternal race, age, smoking, drinking, education, occupation, employment, and marital status; maternal medical and obstetric histories, including X-ray exposures; prenatal care, including provider characteristics, medications, instructions and special procedures; prior birth control method; and birth order of the offspring.

<sup>1</sup>Symposium lecture paper on "Aftermath of Three Mile Island Accident" delivered at the 56th PAS Annual Meeting, April 20, 1980. The Symposium was sponsored by the Henry C. Frick Educational Commission.

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Dr. Tokuhata was designated by Governor Thornburgh to assume overall management of all Health Research Studies related to the TMI accident.

### C. Congenital/Neonatal Hypothyroidism:

This is a special feature of the Pregnancy Outcome Study being conducted within a 10-mile radius. By Pennsylvania law, all newborn babies must be screened for hypothyroidism since July 1978. The screening consists of two-stage testing, i.e.; first, *low T4* (thyroxin) and *high TSH* (pituitary thyroid stimulating hormone) on filter paper and, second, *low T4* and *high TSH* on serum test.

The reason for this study is that (a) certain amount of radioactive iodine ( $^{131}\text{I}$ ) was released from the damaged nuclear reactor during the crisis; and (b)  $^{131}\text{I}$  can be taken up by pregnant women which, in turn, by the fetal thyroid gland through placenta, possibly resulting in congenital hypothyroidism.

The fetal thyroid gland is much more sensitive to radioactive iodine than is the mother's thyroid gland, i.e., a relatively small dose to the mother can be a relatively large dose to the fetus.

In a normal population the incidence of congenital hypothyroidism is approximately one in 4,500 to 5,000 infants. There are several different diagnostic classes, namely: genetic (autosomal recessive; dominant) type, resulting from dysmorphogenesis; ectopic type (dysgenesis), indicating incomplete or improper development of the thyroid gland; agenesis (without thyroid gland); and other types.

During the March 28, 1979-March 27, 1980 period only one case of congenital hypothyroidism was identified within a 10-mile radius among approximately 4,000 infants; this is well within a normal range.

### D. Health Behavioral (Stress) Study:

Shortly after the nuclear accident we recognized that one of the major concerns was the *psychological impact upon health* among local residents. The Pennsylvania Department of Health approached the Department of Behavioral Science at the Hershey Medical Center to conduct such a study in the TMI area as a joint endeavor. A number of related questions needed to be answered:

1. How many (and %) people in the area felt *emotional stress*?
2. How did they *cope* with the crisis situation?
3. What *social and medical/health services* were utilized by those who were disturbed by the accident?
4. What kind of psychosomatic symptoms were reported?
5. Is the psychological impact short-lived or long-lasting?

The initial survey was conducted in July, 1979 and the second survey in January, 1980. Some of the results (Part I) of this study will be presented this evening by Dr. Peter Houts of the Hershey Medical Center.

### E. Health Economics Study:

Apart from the health impact of the TMI accident we recognized the need for conducting a health economics study. This study was designed to assess immediate and short-term excess health costs due to TMI. Health costs are divided into *direct costs*, including those related to medication, evacuation, and other personal health expenditures; and *indirect costs*, including productivity losses due to absenteeism during the crisis. Both individual-family costs and institutional costs (e.g., hospitals and nursing homes) will be considered. For this study we approached the Department of Economics of the Pennsylvania State University; Dr. Teh-wei Hu is the Project Director

and is being assisted by the Pennsylvania Department of Health's staff.

The assessment of economic costs to households is derived from the same telephone survey conducted by an independent research firm serving also the Health Behavioral (Stress) Study. In other words, the same panel of respondents (approximately 700) chosen randomly was used for these two studies.

### F. Radiation Dose Assessment:

One of the most sensitive and technically difficult tasks was to evaluate the extent to which local residents may have been exposed to radiation from the damaged nuclear facility. While no direct radiation measurements were taken on an individual basis (except for some 700 local residents who subjected themselves to whole-body counts sponsored by NRC during the crisis), available TLD (thermonuclear luminescent dosimeter) recordings and other source data monitored by various agencies are useful for such a purpose. We negotiated with the Department of Radiation Health (Dr. David Gur, Project Director), University of Pittsburgh Graduate School of Public Health to conduct this particular study.

Radiation Dose Assessment is directed toward every person resident within the 5-mile radius during the nuclear crisis and every pregnant woman resident within the 10-mile radius during the same period. From the 5-mile census data and 10-mile pregnancy study data, it is possible to reestablish detailed account of whereabouts during the 10-day period of all individuals including those who evacuated, as well as those who left the area for other reasons. In addition, detailed meteorological data including wind direction and velocity, as well as plume-dispersion patterns are being incorporated into the combined monitored radiation dose materials from all reliable sources. With the application of computer mapping technology and elaborate sector analysis, it will be possible to assign (estimate) a reasonably accurate dosage to an individual in the study area during the ten-day period.

It is our hope that the results of this particular study be useful for a variety of current and future studies of possible health effects, particularly from the radiation standpoint.

### G. Cytogenetic (Chromosome) Study:

During the early stage of the development of TMI Health Research Program, when the level of radiation emission was not clearly defined, we recommended that a cytogenetic study be carried out to investigate if the incidence of chromosome breakage in human blood cells is unusually elevated among local residents, including those who are employed by the TMI facility and residents living near the facility. Ionizing radiation, if the dose is high enough, is known to be mutagenic and teratogenic and can cause physical damage to chromosome structure.

The TMI Advisory Panel for Health Research Studies recommended to cancel this particular study on the grounds that (a) the amount of radiation emitted in the area was very small, and (b) the cost of the study would be too high to detect a minute difference (increment in chromosome anomalies) that may or may not be present.

### H. Cardiac Mortality Study:

During the TMI crisis, there was diffuse and heightened levels of anxiety, fear of unknown, and deep feelings of despair and helplessness among local residents, particularly those who



were living within a 15-mile radius. Whether or not such a psychological disturbance affected those adults who had chronic heart conditions became an epidemiological interest. To answer this question, we plan to compare the cardiac mortality rate within the 15-mile area for a six-month period beginning at March 28, 1979 with that for the same six-month period beginning at March 28, 1980 (one year post-accident) and same beginning at March 28, 1978 (one year pre-accident), all in relation to the State average cardiac mortality rate for the same six-month period. For these comparisons, age, sex, and race factors will be taken into account.

#### I. *Family Breakage (Divorce) Study:*

How did TMI nuclear accident affect the family bond in the area in terms of either unification or disruption? To look at possible such effect we plan to conduct a descriptive study designed to determine if the *divorce rate* in the TMI area has *changed* (increased or decreased) after the March 28 accident.

The divorce rate during the March 28, 1979-March 27, 1980 period will be compared to that during a comparable period one year before (control) and one year after (control), all in relation to the State average divorce rate during the same period. Available information regarding sociodemographic characteristics will be taken into account.

#### J. *Mental Health Study:*

An in-depth epidemiological study of psychological impact in a more psychiatric context is being conducted by Western Psychiatric Research Institute. This study, financed by the National Institute of Mental Health, covers three selected "high risk" groups in the TMI area, namely: (1) TMI employees, (2) mothers with small children, and (3) mental health clinic patients.

#### K. *Long-Term Disease Surveillance:*

Although the level of radiation releases from the TMI was very low, there is still some disagreement among epidemiologists and radiation biologists as to the health effects of low level radiation in general. Furthermore, there is some indication that the heightened levels of anxiety and emotional distress will continue to exist among local residents. For these reasons, a long-term epidemiological surveillance of the local population is indicated. This view is consistent with the recommendations made by both the Presidential Commission on TMI and the Pennsylvania Commission on TMI.

Probably the most viable vehicle for such an undertaking would be to make use of the already completed special TMI census. Our immediate and long-term plan is to *update* annually the *Population Registry* now being finalized for an indefinite period of years. During the course of update, numbers and causes of deaths in the cohort can be identified annually. Periodically (e.g., every three or five years) a special morbidity survey may be conducted to determine the incidence and distribution of various diseases and conditions

within the same original cohort of approximately 37,000 persons.

*Cancer mortality* by specific organ sites and by demographic characteristics will be evaluated on an annual basis and adjusted cancer death rates compared historically, as well in relation to the State average rates. When Statewide or regional tumor registry (an expensive undertaking) is instituted in Pennsylvania, it will be possible to evaluate *cancer incidence* within the same TMI cohort. It may also be possible, although not the best alternative, to conduct a cancer incidence study by mail and other feasible means without tumor registry as such. These and other related logistic, fiscal, and technical issues must be dealt with in the near future.

Subsequent to the *Pregnancy Outcome Study* described earlier, we plan to conduct a five-year epidemiological study of *Child Growth and Development* based on the 4,000 infants already ascertained within the 10-mile radius. This would be a joint study with the Department of Pediatrics, Hershey Medical Center. Both physical growth and psycho-behavioral development will be assessed at each anniversary and the results will be compared with national norms already established for possible significant differences. In addition, certain selected cancers, thyroid disorders, and other clinical manifestations will be investigated by pediatricians.

### SUMMARY

The TMI nuclear accident has caused an extensive social-political unrest worldwide. At the same time, it has presented social scientists and biomedical investigators a unique opportunity to evaluate its impact upon local population. Probably the most important concern is that of safety and health effects of the accident.

From the currently available epidemiological knowledge, no significant physical health effects are expected from the low level radiation released from the damaged TMI facility. However, some substantial psychological impacts are apparent. It is not known, at this time, how long such psychological disturbance will continue, to what extent "reported" psychosomatic symptoms are true, and what significant physical manifestations may actually ensue over an extended period of years. In addition, careful evaluation of pregnancy outcome, both immediate and long-term in the local population, should be pursued because of high sensitivity of the fetus to ionizing radiation and severe stress.

I believe it is the responsibility of government agencies and academic communities to properly inform the general public with the objective results of carefully-designed scientific studies of possible health effects of the TMI accident. It is also critical that safety of nuclear energy is properly addressed in relation to that of other available means of energy production. Equally important is the public understanding of various alternatives, so that the society can make a rational choice for its constituents. It is hoped that TMI Health Effect Research Program will serve as a means to achieve such goals.

## EXTENT AND DURATION OF PSYCHOLOGICAL DISTRESS OF PERSONS IN THE VICINITY OF THREE MILE ISLAND<sup>1</sup>

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### ABSTRACT

The "nuclear incident" at the Three Mile Island (TMI) nuclear power plant, beginning on March 28, 1979, resulted in widespread fear on the part of the surrounding population, and the temporary evacuation of a substantial portion of the people in the immediate vicinity of the plant (Houts, *et al.*, 1980). Since the event, there has been continuous publicity about the situation at the crippled reactor with the result that, what began as a brief crisis, has become an ongoing situation with, as yet, no clear resolution.

The purpose of this paper is to describe the psychological responses of persons living in the vicinity of TMI at the time of the initial crisis as well as three and nine months later. We wish to describe three relatively distinct features of this reaction: (1) feelings of overall concern; (2) effects on self-reports of stress-related somatic and behavioral symptoms; and (3) effects on responses to the Langner (1967) index of psychological distress.

### BACKGROUND

There is a substantial literature on the psychological impact of natural and man-made disasters. A variety of situations have been studied, ranging from large-scale events, such as floods or earthquakes, to localized but highly intense ones, such as tornados, and flasi, floods. Overt psychiatric symptomology has been the most common object of study (e.g. Rangell, 1976, Hudgens, 1974, Lifton, *et al.*, 1976), but researchers have also dealt with generalized subclinical distress (Moore, *et al.*, 1959) and with physical symptoms (Melick, 1978, Logue, *et al.*, 1979). At least two prior studies have attempted to determine the extent to which disasters produce long-term distress. One, (Moore *et al.*, 1959), measured the proportion of families containing one or more members who continued to experience "emotional stress" four months after a tornado, while a second (Logue *et al.*, 1979) obtained a retrospective assessment of families' overall distress during a self-defined recovery period and of the duration of distress for the most severely affected family member. Both studies report evidence of long term psychological distress. Physical symptoms have also been studied by Melick, (1978), using retrospective reports of overall health status. She reported an increase in length of illness but not frequency of illness.

<sup>1</sup>Symposium lecture paper on "Aftermath of Three Mile Island Accident" delivered at the 56th PAS Annual Meeting, April 20, 1980. The Symposium was sponsored by the Henry C. Frick Educational Commission.

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While this literature is extensive, it is of limited applicability in understanding responses to the nuclear incident at Three Mile Island. First, all of the disasters analyzed in the works cited above had a vastly greater physical impact than that at Three Mile Island. Even the less severe events, such as the flood described by Melick (1978) and Logue *et al.*, (1979), produced some direct injury, along with a variety of indirect damage in the form of contaminated food and water, exposure to heat and cold stress, loss of suitable sleeping accommodations, and the like. While the accident at Three Mile Island probably did produce some disruption for those who evacuated, the physical magnitude is obviously smaller.

Second, the events at Three Mile Island have so far lacked a sense of resolution. In all of the situations described in the studies cited above, a point was reached when all significant damage had been discovered, and the event could be said to be over. This is much less true of the present situation. Not only does the original source of threat remain, but the population surrounding the plant has been faced with frequent assertions that the original danger was greater than originally thought and that danger may still be present.

Because of the uniqueness of the Three Mile Island crisis, it was not possible to predict degree or type of stress that would be present in the population. The studies reported here assessed perceived mental and physical distress on the part of persons living in the vicinity of the facility. Related studies of health care utilization and of health care providers are also being carried out under sponsorship of the Pennsylvania Department of Health, but are not yet completed.

### METHODS

#### *Sampling and Interview Procedures*

The findings to be reported here come from two sources: (1) a telephone survey of 1506 persons living within 55 miles of the plant, in July, 1979, and (2) a telephone survey of 550 persons within 55 miles of the plant, in January, 1980. The July survey was carried out by the Nuclear Regulatory Commission, and included items on stress-related symptoms and feelings about Three Mile Island. Some items in the July survey referred only to respondents' beliefs and feelings at the time of the crisis in April, while others required information for both April and July. The January survey, which was carried out by Penn State repeated these items, and also included the Langner Index of psychological distress (Langner, 1967).

Both interviews were conducted by Chilton Research Services, a professional interviewing organization in Radnor Pennsylvania. The population to be sampled consisted of all individuals

living within a 15 mile (radius) ring surrounding the plant, and individuals clustered along north-south and east-west transects extending from 15 to 55 miles from the plant (See Flynn, 1979 for a more detailed description of sampling procedures.)

Random digit dialing was used for all telephone exchanges within the designated area, in order to assure access to both listed and unlisted phones. Interviewers were instructed to call until they reached a number which was a home (rather than business) phone, and to establish that the home was within the designated area. They then randomly requested to speak to either the male or female head of household. If this person was not present the opposite-sex head was requested. Numbers with no answer were called up to four times, while those at which an interview had been refused were recalled once. At the beginning of each interview the respondent was read an informed consent statement which described the purpose of the interview and indicated that all responses were voluntary, and would remain confidential.

The July survey achieved a response rate of 69%. That is, 69% of the eligible households yielded a completed interview, while 17% produced a refusal; the remaining 14% could not be completed for some other reason. Rate of response, refusal and non-completion for the January survey were 82%, 11% and 7%, respectively.

#### *Measures and their Interpretation*

Two distinctly different types of questions were included in the surveys. The first type refers to beliefs and attitudes. This includes questions such as "How serious a threat do you feel the Three Mile Island Nuclear Station is for you and your family's safety?" and "How upset do you feel about the situation at Three Mile Island". Responses to questions such as these can usually be taken at face value, since one can generally assume that normal individuals can, if they so choose, give an accurate description of these kinds of states. Some distortion can be expected because of poor memory (if the question refers to a previous belief or attitude) or an unwillingness to acknowledge strong feelings.

The second type of question included in the interviews refers to the occurrence of physical or behavioral symptoms where the process of interpretation is much more complicated. There are at least five factors which may distort respondents' reports of these symptoms during and after the Three Mile Island Crisis.

1. *Memory*—Most of the questions concerning symptoms and health-related behaviors asked respondents to remember events that occurred during the crisis period or during the two weeks just prior to the interview. Since memory is rarely perfect and often selective (i.e. people tend to remember things that they think are important and sometimes forget things that are upsetting), there is ample opportunity for distortion to occur.
2. *Mental Status*—It has been shown (Mechanic, 1972) that persons with poor mental status (e.g. anxiety, confusion, depression, etc.) tend to report more physical symptoms than others. It is not clear whether these people experience more symptoms or whether they simply attend to and remember symptoms which otherwise would have been forgotten. To the extent that it is the latter, people with poor mental status may report inflated symptom rates.
3. *Willingness to Acknowledge Feelings and Symptoms*—Some persons are more open in telling others about their feelings and physical conditions than are others. It has been suggested that this variable may play a role in why women report more symptoms than men and why persons from certain cultural groups

report higher symptom frequencies (Mechanic, 1972).

4. *Attitudes and Commitments*—Many social psychological studies have shown that people tend to remember and report events in a manner that is consistent with their attitudes or their behavior (Festinger, 1957). This tendency could, for example, play a role in what pro or anti nuclear power people remember from their experiences during the crisis.
5. *Conscious Distortion*—It is possible that some respondents consciously distorted their answers in hopes of affecting public policy toward Three Mile Island. For example, a person who is opposed to re-opening TMI might over-state symptoms or feelings which he or she experienced during the crisis in an attempt to influence survey results toward showing that people in the vicinity of the island were experiencing distress.

## RESULTS

The inclusion of persons who live at a considerable distance from the plant has made it possible to use the farthest group, i.e. persons living beyond 40 miles of TMI, as a control group against which to compare responses of persons closer to TMI. By matching persons at different distances on demographic variables (i.e., age, sex, education, income and marital status) we can infer that, if distress is higher close to TMI, that this is related to events at Three Mile Island. (Since not all possible demographic variables have been controlled, we cannot be absolute certain that proximity to Three Mile Island is the only cause of distance effects, only that it is a likely cause.) This analysis can be carried out using multiple regression analysis with dummy variables for each distance group.

It should be pointed out that the distance variable is a conservative indicator of distress due to Three Mile Island. Persons living in the farthest group may have experienced some degree of distress because of the crisis and these effects are lost in comparisons across the distance. Therefore, while we may reasonably infer that, if distress levels are higher close to TMI than farther away, that this is a result of proximity to Three Mile Island, we are not sure that this reflects all the distress that was caused by the crisis and its aftermath.

#### *Interpretation of distress response*

Three types of stress indicators were collected in these surveys: (1) direct statements about how worried, upset, etc. respondents have been about the situation at Three Mile Island, (2) the Langner index of psychological distress (Langner, 1967), and (3) respondents' reports of mental and physical symptoms that are often associated with stress. The stress-related symptoms used in this study were drawn from research on stress (Selye, 1955) as well as from interviews with patients at the Hershey Medical Center and in the practice of Dr. Joseph Leaser in Middletown, Pa., immediately following the crisis. These stress-related symptoms were broken into two groups, based on a factor analysis. The first group, which deals primarily with physical symptoms, includes headaches, diarrhea, constipation, abdominal pain, sweating spells, stomach trouble, frequent urination and rash, and we will call this group "physical stress symptoms." The second group, which deals with overt behaviors, includes irritability, fits of anger, sleeplessness, loss of appetite, feeling trembly, trouble thinking, and overeating. We will call this second group "behavioral stress symptoms." Results will be discussed separately for the two groups of symptoms.

The three areas of interest noted above—feelings of overall concern, reports of stress-related physical and somatic symp-



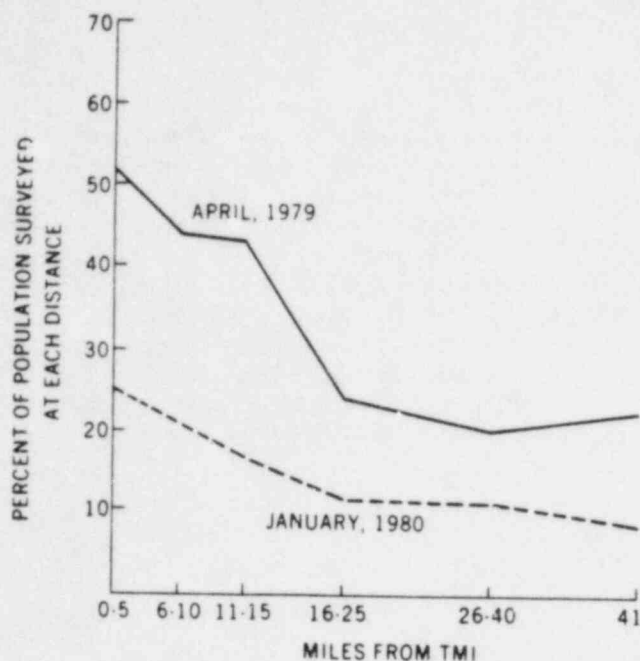


FIGURE 1. % of respondents extremely upset or quite upset about TMI

toms, and responses to the Langner index of psychological distress—will be discussed separately and then compared. In each case we will present responses as a function of distance from the plant, first as absolute scores, and then as percentages corrected for demographic variables and plotted as differences from the 40 mile control group.

#### Feelings of concern about TMI

Two questions concerning feelings about TMI were asked in both the July 1979 survey as well as in the January 1980 survey. Results will be reported separately for each question. The first question asked about how upset the respondent was about TMI. The exact phrasing was as follows.

(1) How upset do (did) you feel about the situation at Three Mile Island?

extremely upset  
quite upset  
somewhat upset  
a little upset  
not at all upset  
don't know

This question was asked twice; first in the July 1979 survey when respondents were asked how they had felt in April 1979, during the crisis period, and, second, in the January 1980 survey when they were asked how upset they presently felt.

Results are reported in figures 1 and 2. Data are presented in two ways. First is the percent of persons within each distance group who reported being extremely or quite upset about the situation at Three Mile Island (figure 1). This chart shows a sharp overall drop from April 1979 to January 1980, though both lines are higher close to TMI. It is interesting to note that, even in the farthest group, over 20% were extremely or very upset in April and 7% still felt this way in July. This indicates, as suggested earlier, that distress was experienced to some degree even in the farthest group.

Second, these same data are reported after using multiple regression analysis to control for a number of demographic variables (age, sex, education, income and marital status), which dif-

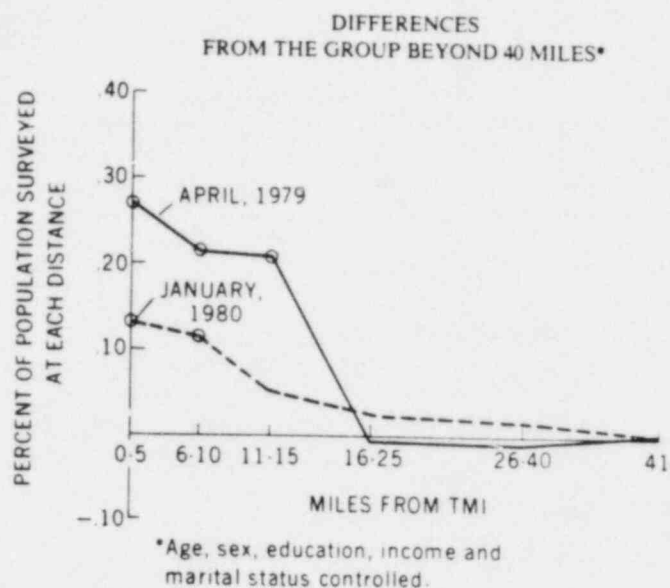


FIGURE 2. Ratings of extremely upset or very upset about TMI. A circled point indicates that the percent of persons who are extremely or very upset about TMI at that distance is significantly greater than the percent of persons beyond 40 miles who are extremely or very upset.

ferred somewhat at different distances, and, therefore, may have distorted the results. These "refined" results are shown in figure 2 in terms of variations from the farthest group (beyond 40 miles). Figure 2 also shows where response levels are significantly different from the response levels beyond 40 miles when age, sex, education, income and marital status have been controlled.

Figure 2 shows a marked distance effect in April, 1979 immediately following TMI, as well as in January, 1980, though the percentages for January within 15 miles are half what they were in April. In April, the probabilities of being extremely or very upset are significantly higher than the farthest group for the 0-5, 6-10 and 11-15 mile groups and then drop to below the level of

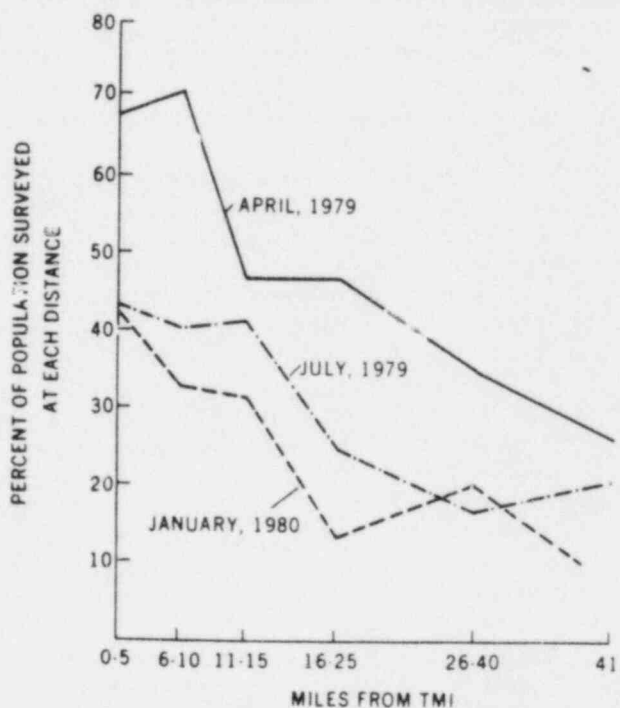


FIGURE 3. % of respondents who feel TMI is a serious threat or very serious threat to their families' safety

statistical significance beyond that. In January, they are significantly different for only the 0-5 and 6-10 mile groups.

The second question concerns perceived threat to the respondent and his or her family. This question was phrased as follows. How serious a threat do (did) you feel the Three Mile Island Nuclear Station is (was) for you and your family's safety?

a very serious threat  
a serious threat  
some what of a threat  
no threat at all  
don't know

This question was asked in the July, 1979 survey about how respondents had felt in April, immediately following the accident as well as for how they felt in July. The same question was also asked in the January survey for how respondents felt in January.

Results are shown in figures 3 and 4. The methods of analysis were the same as for the previous question and the findings are strikingly similar. While the overall percentages dropped sharply from April to July, (figure 3), there was relatively little change from July, 1979 to January, 1980. When the three time periods are plotted as deviations from the farthest group with demographic variables controlled (figure 4), the three time periods are strikingly similar. There is a 10 percent drop from April to July with January scores between the two. For all three times the 0-5, 6-10 and 11-15 mile groups are significantly higher than the group beyond 40 miles.

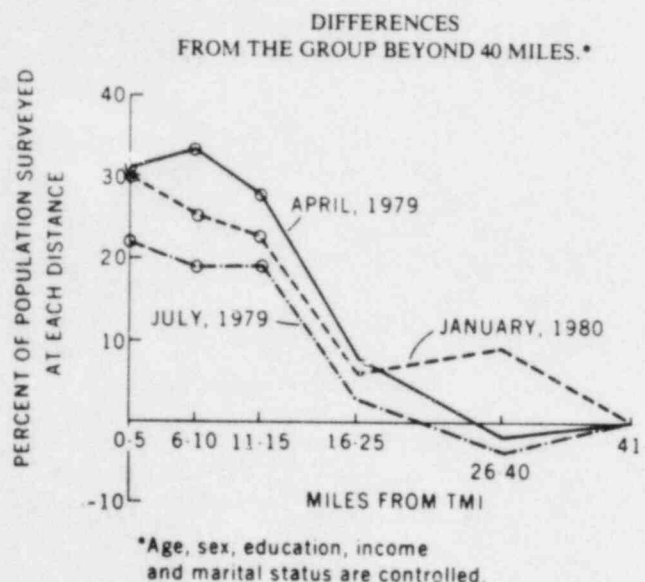


FIGURE 4. Ratings of very serious or serious threat to family's safety. A circled point indicates that the percent of persons feeling that TMI is a very serious threat or serious threat at that distance is significantly greater than the percent of persons beyond 40 miles who feel TMI is a very serious or serious threat.

#### Symptom Reporting

The frequency of reported physical stress symptoms (i.e. headache, diarrhea, constipation, abdominal pain, sweating spells, stomach trouble, frequent urination and rash) is summarized in figures 5 and 6. Results are reported in terms of percent of persons who reported at least one of these symptoms for each time period. Data analysis and presentation format are the same as for the two questions cited earlier.

The percent distributions, shown in figure 5, show large overall differences for April, July and January. The highest rates are reported in January, followed by July and then April. The fact

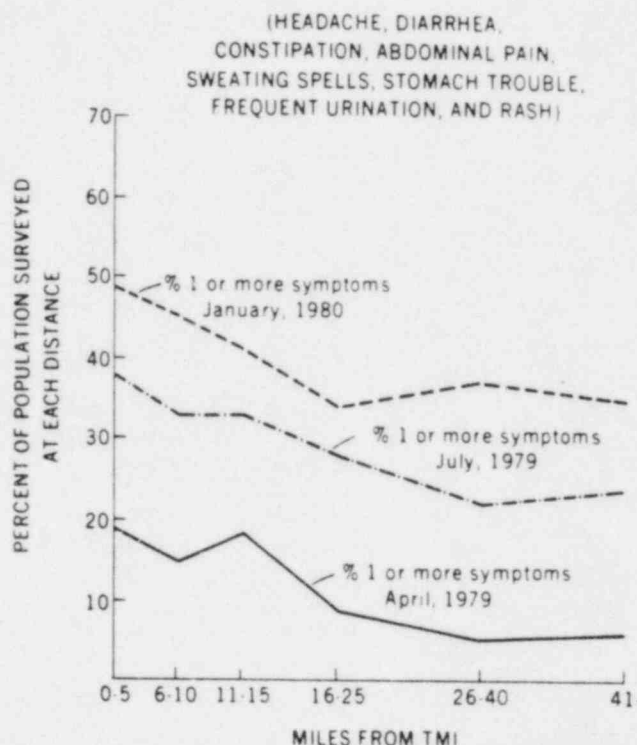


FIGURE 5. Percent of respondents with one or more physical stress symptoms

that July rates are higher than April is probably due to memory since both sets of data were collected in July. That is, in answering about April, respondents had to remember back three months, but in answering about July, they only had to remember for the two weeks just prior to the interview. The higher rates for January may be due to seasonal variations in symptom reporting. The Health Interview Survey, a nationwide survey conducted by the National Center for Health Statistics, reports that acute symptoms are, on the average, 1.4 times higher in January than in July (DHEW Publication No. (PHS) 79-1560). This is approximately the same as the differences found here.

The fact that all three sets of data slope suggests that, as with the attitude measures reported earlier, closeness to TMI did have an influence on symptom reporting. Figure 6 makes this point more convincingly. Here, demographic variables (age, sex, education, income and marital status) have been controlled and probabilities are plotted as deviations from the control group (beyond 40 miles), this eliminates the general level differences and allows comparisons of the slopes alone. Figure 6 not only shows raised response frequencies close to TMI, it also shows a sharp drop between 15 and 25 miles, the same as with the attitude data. Statistical significance, as shown in figure 6 also drops after 15 miles. The percent of the population above baseline at all three times is approximately ten percent.

Analysis of behavioral stress symptoms (i.e. loss of appetite, overeating, trouble sleeping, feeling trembly or shaky, trouble thinking clearly, irritability and extreme anger) is shown in figures 8 and 9. The method of analysis and presentation parallels those reported earlier. Figure 7 shows the same general differences among the three time periods that were found with the "physical" stress symptoms. These are probably due to the same causes. Figure 8, which includes controls for demographic variables as well as differences in general levels, again shows significantly higher levels of symptom reporting out to 15 miles for April and January, but only for the 0-5 mile and 11-15 miles



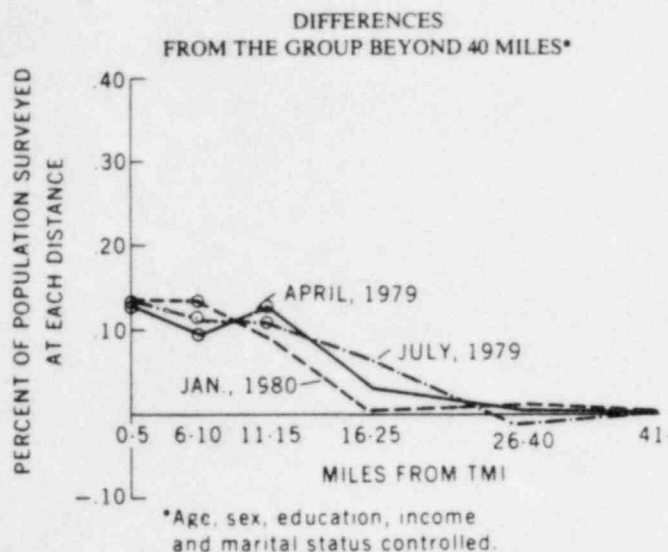


FIGURE 6. One or more physical stress symptoms  
A circled point indicates that the percent of persons who report at least one symptom at that distance is significantly greater than the percent of persons beyond 40 miles who report at least one symptom.

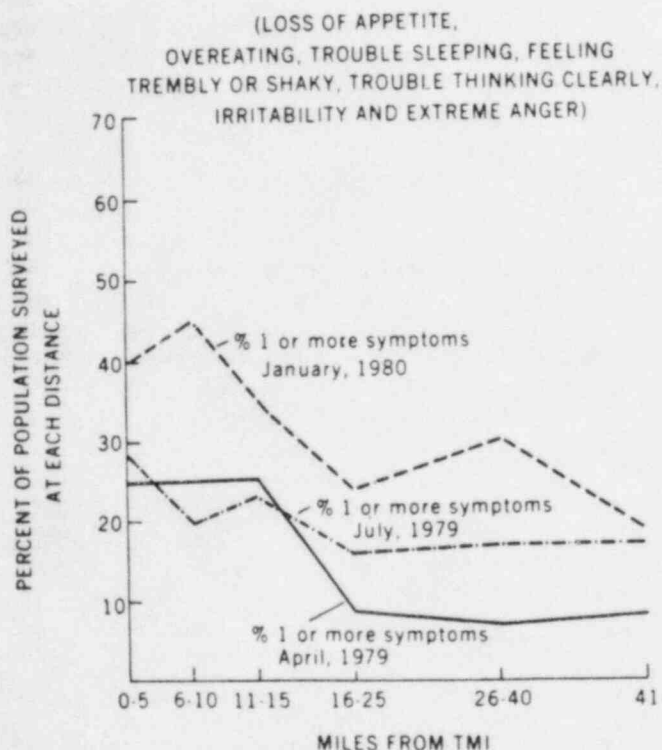


FIGURE 7. % of respondents with one or more behavioral stress symptoms.

groups during July. Figure 8 also shows the highest rates within 15 miles for January, followed by April and July. There is also a rise in symptom reporting in January for the 26-40 mile group, but this is not significantly different from the group beyond 40 miles. In general, this figure repeats the patterns of the other measures, showing raised levels of symptom reporting out to 15 miles for April, July and January.

#### Psychological Distress

The last set of data to be reported here are responses to the Langner index of psychological distress, which was included only in the January survey. This scale includes questions about de-

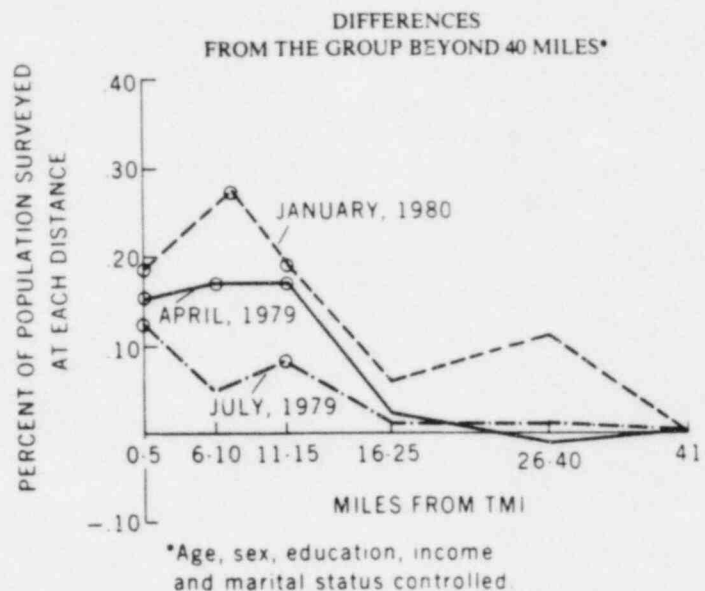


FIGURE 8. One or more behavioral stress symptoms.  
A circled point indicates that the percent of persons who report at least one symptom at that distance is significantly greater than the percent of persons beyond 40 miles who report at least one symptom.

pression, anxiety and some psychosomatic symptoms. Data were analyzed in the same manner as for the other distress indices. However, in this case, there were no statistically significant differences between groups close to TMI and the farthest comparison group.

#### DISCUSSION

As was pointed out earlier, there are a number of variables that can affect symptom reporting rates in addition to actually having symptoms. As a result, we cannot be certain that what people report is the same as what they experienced. However, it is possible to make some inferences from the general pattern of results that do not require accepting responses at face value.

While there are several possible explanations for why symptom reporting is higher near TMI than farther away, they all indicate higher levels of stress near the Island. For example, if poor mental status (e.g. anxiety, depression, etc.) caused the higher reporting rates, poor mental status is, itself an indicator of distress. If the higher reporting rates near TMI are due to strong negative attitudes toward TMI which lead people to notice and remember symptoms, this too, indicates higher distress near the Island. Finally, if conscious distortion played a role in raising rates, this too can be considered an indicator of distress, since it would be expected only where feelings are very strong. As a result, it is possible to conclude that distress (whether expressed through actual symptoms, increased tendency to notice and remember symptoms or conscious distortion in reporting symptoms) is higher close to Three Mile Island.

The similarity between findings for attitudes and for stress-related symptoms is striking. Both sets of data show raised levels of distress out to 15 miles and both sets of data indicate essentially the same pattern for April, July and January. This suggests that they are reflecting the same underlying distress levels. The fact that the Langner scale shows a different pattern from the other distress measures suggests that it may be measuring a different degree of distress or a different type of distress than are questions

about attitudes or stress-related symptoms. An examination of items in the Langner scale suggests that both may be the case. For example, the Langner scale asks if the respondent is often troubled with headaches, while the stress-related symptom items only ask whether the respondent had experienced a headache in the past two weeks. Also, the Langner scale includes questions about depression as well as psychosomatic symptoms not included in either the physical stress or behavioral stress symptom lists.

A detailed analysis of each of the items in the Langner index and the stress-related symptom lists supports this interpretation. Several items in the Langner index allow for three responses: never, sometimes or often. The usual Langner scoring of these items is to only count "often" as a positive response. When this is done, none of these items show an increase close to TMI. However, when the response "sometimes" is also included, a procedure which makes the scoring more comparable to the PSU and NRC studies, a distance effect is seen, but only for those items which overlap with the stress-related symptom lists. This indicates that differences in both type and severity of symptoms assessed contribute to the different findings with these two distress measures.

#### *Relationship of these findings to other studies*

This is one of several studies concerned with the psychological effects of the Three Mile Island incident. Of those made public to date the one which overlaps most with this work is the report by the Task Force on Behavioral Effects of the President's Commission on the Accident at Three Mile Island (Dohrenwend et al., 1979).

The task force report included findings for several different sub-groups including workers at TMI, mothers of young children, as well as some general population data. Since much of the task force's work concerned sub-groups, it is not directly relevant to the findings reported here. However, two specific findings are relevant: (1) The results of three administrations of the "demoralization" scale to persons within 20 miles of TMI and one administration to a control group in Wilkes-Barre, Pennsylvania and (2) The results of three administrations of "distrust of authorities" scale to persons within 20 miles of TMI and one administration to a control group in Wilkes-Barre. The "demoralization" scale is made up of questions that are very similar to questions in the Langner scale used in our studies. In fact, the two scales share some of the same items and the correlation between the Langner and demoralization scales is over .90, which makes them essentially equivalent. The distrust of authority scale includes questions about trust in federal or utility company officials regarding safety of TMI and whether respondents feel state or federal officials had been truthful. With this in mind, we will review the findings of the two studies.

The Presidential Commission Task Force found that demoralization scores were markedly raised among persons interviewed in April, immediately after the accident, but that they fell sharply in a second sample in May and showed a small additional drop in a third sample in July. A comparison of demoralization scores of mothers with small children in the vicinity of TMI and in Wilkes-Barre showed no significant difference in July. These facts led the task force researchers to conclude that, on this measure of distress, the population had returned to baseline by July. The task force findings are consistent with the findings reported here for the Langner index. In January, we, too found no differences in Langner scale scores between persons living close to TMI and persons living beyond 40 miles. In this respect, the results of the two studies are consistent.

The second task force measure involved the "distrust of authority" scale. The task force reported that the level of distrust was markedly elevated immediately following the accident and that it dropped slightly in May with a slight additional drop in July. However, they also found in July that it was higher near TMI than in a control group Wilkes-Barre, Pa. They also compared responses in July to results of a national survey which included similar questions. They concluded that, even in July, distrust near TMI was above the national level. These findings show a similar pattern to those reported here where ratings of upset and concern about safety of TMI were elevated near TMI in both April and July in comparison to persons living beyond 40 miles.

While the report of the presidential task force and the studies reported here are in substantial agreement, this may not appear to be the case from reading the summary statement of the Presidential Commission on Three Mile Island (Kemeny, et. al., 1979). This is because writers of the summary report (who were not the same people who wrote the task force report) included only the findings from the Demoralization scale in their discussion of long term effects and ignored the findings about trust in authority. Their conclusion that "There was immediate, *short-lived* mental distress produced by the accident among certain groups of the general population . . ." is correct if, by mental distress, is meant only behaviors assessed by the demoralization scale (and the Langner scale). However, long term effects through July were shown in the task force studies in the form of distrust of authority. In our study, long term effects were demonstrated through January 1980 in the form of being upset about TMI, concern about safety of self and family, and, closely related to these, awareness and reporting of symptoms frequently associated with stress.

## SUMMARY

Between ten and twenty percent of the population within 15 miles of TMI had heightened levels of distress (compared to persons beyond 40 miles from TMI) as indicated by statements of being upset about TMI, concern about safety for themselves and their families and reporting of symptoms frequently associated with stress. This distress, which began during the crisis period, continued into January, 1980, nine months after the original crisis.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge the help of Dr. Cynthia Bullock Flynn, Michael Kaltman, Nancy Kreuser, Carol DeGennaro, Dr. Joseph Leaser, Dr. David Mechanic, and Paul Cleary.

Funds for this work were provided, in part, by the Electric Power Institute through a contract with the Pennsylvania Department of Health.

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