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THE EFFECTS OF THE ACCIDENT AT THREE MILE ISLAND ON THE MENTAL HEALTH AND BEHAVIORAL RESPONSES OF THE GENERAL POPULATION AND THE NUCLEAR WORKERS

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DISCLAIMER

THE EFFECTS OF THE ACCIDENT AT THREE MILE ISLAND ON THE MENTAL HEALTH AND BEHAVIORAL RESPONSES OF THE GENERAL POPULATION AND THE NUCLEAR WORKERS[1,2]

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INTRODUCTION

At 4:00 a.m. on March 28, 1979, the United States experienced the worst accident in the history of commercial nuclear power generation [TMI79a; NRC79a; NRC79c]. This serious accident occurred at the Three Mile Island 2 nuclear power plant near Middleton, Pennsylvania. The accident was initiated by mechanical malfunctions in the plant and made much worse by a combination of human errors responding to it. During the next four days, the extent and gravity of the accident was unclear to the utility's managers of the nuclear power plant, to the federal and state officials, and to the general public. Two weeks later the President of the United States established a Commission to conduct a comprehensive study and investigation of the accident involving the nuclear power facility at Three Mile Island (TMI). The Commission's study and investigation included "an evaluation of the actual and potential impact of the events on the public health and safety and on the health and safety of the workers" [TMI79b].

Just how serious was the accident? Based on the investigations of the President's Commission into the health effects of the accident, it was concluded that in spite of serious damage to the nuclear plant, most of the radiation was contained and the actual release of radioactivity will have a negligible effect on the physical health of individuals. The major health effect of the accident---in the general population and in the nuclear workers---was found to be mental stress [TMI79b].

The highly publicized events during the early days of the accident---the various releases of radioactivity into the atmosphere and into the Susquehanna River, the generation and accumulation of a large hydrogen bubble in the reactor-pressure vessel, the risk of major releases of large amounts of radioactive debris from the damaged nuclear core, and the possibility of these events presenting a great threat to life---led to Pennsylvania's Governor Richard Thornburgh's advisories that all people living or working within a 10-mile radius of Three Mile Island remain indoors, and all pregnant women and preschool age children living within 5 miles of the nuclear plant leave the area immediately. Nearby schools were closed. Plans were considered for evacuation of almost a third of a million residents. Although these plans were never carried out in the form of an official order, a large number of families decided to leave the area voluntarily. A main conclusion drawn from the investigation by the President's Commission was that the most serious health effect of the Three Mile Island nuclear accident was severe mental stress, which was short-lived. The highest levels of psychological distress were found among those living within 5 miles of Three Mile Island, in families with preschool children, and among the Three Mile Island nuclear workers.

My assignment this afternoon is to provide you with some understanding of how these conclusions were drawn, the methods used to obtain information on the experiences of mental stress and the behavioral effects and responses of the general population and the nuclear workers to the accident at Three Mile Island. In order to limit the scope of my discussion, I have chosen to draw heavily from our Behavioral Effects Task Group Report [TMI79c] to the President's Commission, and thus from the labors of the many behavioral scientists with whom I worked indefatigably during the summer of 1979.

WHAT HAPPENED AT THREE MILE ISLAND?

In order to place the events of the nuclear accident at Three Mile Island, which may have had considerable psychological effect, into perspective it would be of value to limit the discussion to those events which received wide news media coverage [TMI79d; NRC79c], particularly the confusion and response of government authorities, the extent of the accident and the possibility of a life-threatening explosion, and the emergency response for evacuation of the area, and to those important events of the first two weeks of the nuclear accident.

The nuclear power reactor involved was Unit-2 of the Three Mile Island Nuclear Power plant, which consists of two nuclear power units of 792 and 800 megawatts electrical generating capacity [TMI79e; NRC79a]. The reactors are pressurized water reactor types and were supplied by the Babcock and Wilcox Company. Commerical operation of the first unit began in September 1974 and operation of the second began in May 1978. The Metropolitan Edison Company operates the plants for a consortium of utilities owned by General Public Utilities Corporation. The plant is located on a small island in the Susquehanna River at Goldsboro, Pennsylvania, about 10 miles southeast of Harrisburg, the capitol of the Commonwealth of Pennsylvania.

On March 28, 1979, an accident occurred at the Three Mile Island nuclear power plant, near Harrisburg, Pennsylvania, which became the most serious nuclear accident in the United States to date. It caused the governor to close nearby schools, and to advise pregnant women and preschool age children within 5 miles of the site to leave, and people within a 10-mile radius to stay inside their homes or place of work. Evacuation of from 200 to 300 thousand residents from a 20-mile area was planned but was not ordered. The accident caused public fear and confusion, some voluntary evacuation, large numbers of people left the area, and renewed controversy over the safety of nuclear power. No injuries or casualities to the public occurred, although there was some exposure of nearby residents to very small amounts of radiation which had been released to the environment [NRC79a; NRC79c; TMI79b; TMIc].

Some nuclear workers received low-level radiation exposures, although not enough to cause any short-term injury [TMI79f]. Detectable quantities or radioactive materials were found in the environment, but well below limits that would cause official concern and protective action [ICRP77]. At its peak, the accident presented the potential but unknown risk of a significant release of radioactive materials from the core of the damaged reactor. By two weeks after the accident, the peak danger had passed and the damaged reactor core was in stable shut-down condition. Even today, a long and expensive decontamination still remains to be done before the reactor can return to service, and it is still not clear where all the radioactive debris can be sent for disposal.

The nuclear accident immediately triggered numerous congressional and executive branch and industry-wide investigations regarding reasons for it, the government's and the industry's response, the future of this nuclear plant, the risk that similar nuclear power plants may present and what to do about that risk, and the future of nuclear power in the United States, if not throughout the world [NRC79b; NRC79c; We79]. Many government hearings were held. Legislation to strengthen regulation of nuclear power plant safety was rapidly

brought before the legislative branches of numerous governments throughout the Western world.

The events of the nuclear accident was now well understood [TMI79e; TMI79g; TMI79h; TMI79i; NRC79a]. The accident began at 4:00 a.m. on Wednesday, March 28, 1979, when the Unit-2 reactor (the newer one) was at about 98% power during routine on-line maintenance. At the time, Unit-1 was shut down for refueling. The initial mishap set off a series of equipment failures and mistakes in operator judgement that culminated in a real risk of uncertain degree of dangerous exposure of the public to radiation. The risk came from the possibility---which was emphasized in the news media coverage---that some part of the reactor's intensely radioactive core might melt and escape from the reactor and its containment into the environment. A related fear emphasized in the press, but later discredited, was that hydrogen gas which had accumulated within the reactor might explode violently and disperse some of the core and its radioactive material into the environment over an area of many miles.

By April 3, 1979, the risks of a potential catastrophic release of radioactivity from the crippled reactor were over. Federal officials stressed that while the situation seemed under control, extreme care would be needed to confine the released radioactive materials within the reactor and its containment. Mr. Harold Denton, Director of NRC's Office of Nuclear Reactor Regulation, said there should be no rush to get the reactor totally shut down but, rather, the process should move slowly. The press also reported that officials conceded they may have taken a somewhat too alarmist view of the imminence of the threat of a hydrogen gas explosion [Wa79; NRC79c].

HOW MUCH RADIOACTIVITY ESCAPED FROM THE ACCIDENT AND WHAT WERE ITS HEALTH EFFECTS?

The accident caused some releases of radioactive materials [Ba79; NRC79a; TMI79f]. During the first day, a plume of slightly radioactive material about half a mile wide moved north from the nuclear plant. There was daily aerial monitoring of the plume. News reports of radiation monitoring in Maryland, New Jersey, and New York indicated no unusual changes and the analyses of milk, food and water samples showed no increases in radioactivity over normal background levels [NRC79a; Ba79].

The technical staff of the Nuclear Regulatory Commission, the Department of Energy, the Department of Health, Education and Welfare, and the Environmental Protection Agency formed an Ad Hoc Population Dose Assessment Group to assess the health impact of these releases on some 2 million residents living within 50 miles of the accident [Ba79; NRC79a; TMI79f]. Its preliminary assessment was that the offsite collective dose of 3,300 person-rem represented minimal risks (that is, a very small number) of additional health effects to the offsite general population. The projected number of excess fatal cancers due to such exposure over the remaining lifetime of the population of over 2 million people living within 50 miles of Three Mile Island was reported as approximately one, in comparison with about 325,000 fatal cancers normally to be expected in that population under normal circumstances

[Ca79]. The projected total number of excess health effects, including all cases of cancer and genetic ill health to all future generations was estimated at approximately two. The government group noted that a few scientists believe the risk factors were as much as two to ten times greater than that commonly accepted by the greatest majority of the scientific community, while there are other scientists who believe that estimates of the effects of exposure to low doses of radiation are two to ten times larger than they should be [Ba79; BEIR80].

The principal radioactive materials released were radioactive gases of xenon and krypton and some iodine-131. Some information about exposure was obtained from Department of Energy monitoring and from dosimeters of the utility, Metropolitan Edison, and the Nuclear Regulatory Commission [Ba79; NRC79a; TMI79f]. A single precise value for the collective dose to the population could not be assigned because of the limited number of dosimeters, a limited knowledge of the exact number and location of all the individuals in the general population in the 50-mile radius during the accident. Some iodine-131 was found in milk samples, but it was 300 times lower than the level at which the Food and Drug Administration would recommend that cows be removed from contaminated pasture. No reactor-produced radioactivity was found in any food samples collected by the Food and Drug Administration during that two-week period [Ba79; NRC79a; TMI79f].

WHAT COULD HAVE HAPPENED AT THREE MILE ISLAND?

The worst thing that can happen in a nuclear power accident is for some of the core to melt and get out of its containment so that dangerous amounts of intensely radioactive materials escape from the reactor and into the environment [NRC74; TMI79g]. Depending upon the form of the release and the weather, populations downwind might be exposed to dangerous amounts of radiation and have to be evacuated, with the contaminated area made unfit for use, perhaps for a long time. On the other hand, the effects might be limited to the immediate vicinity of the accident only. The accident at Three Mile Island was the result of an improbable sequence of events which nonetheless occurred. It is now clear how close the accident came to a catastrophic core meltdown and release of radioactivity to the environment---that could not have occurred. Those who are critical of nuclear energy nevertheless still say that the risk was immediate and great and that disaster was barely averted [NRC79c; Pe79]. That is just not the case. Those who favor nuclear power industry continue to assert that the risk was not that great and note that the accident was contained with no casaulties [We79]. And that is just not the case.

WHY WAS THERE SO MUCH CRITICISM OF THE GOVERNMENT'S RESPONSE DURING THE ACCIDENT?

Local, state and federal officials responded immediately to the Three Mile Island accident, although there was confusion over respective responsibilities and authorities, and it did not seem there was one official with overall responsibility [TMI79; Fa82]. The Nuclear Regulatory Commission sent key officials to the site to enforce Nuclear Regulatory Commission regulations and to offer technical advice. The Nuclear Regulatory Commission was represented

at the site by Harold Denton, Director of the Office of Reactor Regulation, who also served as personal contact with President Jimmy Carter [NRC79c]. The Department of Energy and some of its contractors provided technical advice and assistance, while the Department of Defense provided special communications and some air transport of lead shielding and special equipment. The President visited the site on Sunday, April 1, 1979, and afterwards asked residents living in the area to calmly and exactly carry out whatever instructions might be given if a precautionary evacuation were to be ordered. The confusion over immediate crisis management was reduced somewhat when the Nuclear Regulatory Commission announced April 2, 1979 that it had an unequivocal understanding with the utility company that the Nuclear Regulatory Commission must be informed of and concur in advance to all actions that might change either the rate of release of radioactive gases or the way of cooling the damaged reactor.

For several days there was widespread and sometimes responsible and sometimes irresponsible speculation that evacuation might be ordered if the accident worsened, or as a precaution, and there were frequent press, television, radio, and other news media reports of planning by city and county civil defense directors and other officials for evacuation of as many as 200,000 to 300,000 persons within 25 miles of the plant. Many nearby residents left the area of their own accord.

WHAT WERE THE EVENTS DURING THE ACCIDENT THAT CAUSED THE BEHAVIORAL RESPONSES IN THE GENERAL POPULATION AND THE NUCLEAR WORKERS?

March 28, 1979. There are certain chronological events that could have considerable bearing on the mental stress and behavioral effects of these populations [TMI79a; TMI79c; Fa82; NRC79c]. On March 28, 1979, at approximately 4:00 a.m., at 98% power, the secondary feed pumps of the Three Mile Island Unit-2 in Middletown, Pennsylvania tripped due to a feedwater polishing system problem, thus beginning the accident. AT 7:30 a.m. a General Emergency was then declared due to the high radiation levels in the reactor building. At 11:00 a.m., Nuclear Regulatory Commission investigators and inspectors arrived at the Three Mile Island site. At the same time, the Federal Interagency Radiological Assistance Plan emergency response for environmental monitoring and backup support was initiated by the Department of Energy. An aircraft equipped for airborne radiation monitoring arrived at 2:15 p.m. and began tracking flights.

March 29, 1979. On this date the Nuclear Regulatory Commission officials reported that the failure at the Three Mile Island plant was regarded as the most serious accident in the United States to date. However, they did not know the cause of the accident, the extent of the damage to the plant, or the hazard to the public health. Immediately, Lt. Governor of Pennsylvania, William Scranton III, called a press conference to demand an investigation into an apparent three-hour delay between the time of the incident and when state civil defense authorities were notified of it, whereupon Mayor Robert Reed of Middletown, Pennsylvania complained to the press, radio and television news media that he had not heard of the accident which had occurred at approximately 4:00 a.m. until 8:15 a.m.

Within hours, antinuclear scientists appeared on television, demanding to be heard [NRC79c; We79]. Dr. Ernest Sternglass of the University of Pittsburgh immediately declared that pregnant women within two miles of the site probably should be evacuated. Dr. George Wald, a biologist at Harvard University and 1967 Nobel prize winner, said the harmful health effects of the nuclear accident would be long-range and probably would not show up for 30 to 40 years in increased cancer rates. The congressional and White House leaders were soon heard. A congressional delegation headed by Senator Gary Hart of Colorado visited the site that day to ascertain the potential harm to the public's health and safety [TMI79a; NRC79c]. Senator Edward Kennedy of Massachusetts immediately proposed new legislation that day to slow down the licensing of all nuclear reactors. White House Press Secretary Jody Powell said that President Carter was concerned about the radiation leak at Harrisburg and was getting information on it from the National Security Council Chief Zbigniew Brzezinski [NRC79c]. It was learned later that for three days Brzezinski was in charge of the problem at the White House simply because when the telephone call about the nuclear power plant accident came in to the White House, the telephone operator directed the call to the office of the National Security Council, since the Council's responsibilities included nuclear war, nuclear weapons proliferation, and nuclear disarmament treaties. The Council's senior assistant immediately relayed the message to Brzezinski, who apparently chose to take charge of this matter in the interest of national security, since he was at that time busy drafting the nuclear weapons and nuclear proliferation disarmament treaty between the United States and Russia [NRC79c; Fa82].

Then, without any discussion, information, or announcement, Metropolitan Edison Company, the utility company at Three Mile Island, released about 50,000 gallons of slightly contaminated industrial wastes not directly connected with the nuclear accident into the Susquehanna River [Pe80]. This unannounced release angered the governor and the Nuclear Regulatory Commission's officials, and was immediately terminated at the Nuclear Regulatory Commission's request at approximately 6:00 p.m. because of concerns expressed by state representatives. However, after assessing the situation all evening, at about 12:15 a.m. early the next morning, the Nuclear Regulatory Commission gave Metropolitan Edison permission to resume releases of slightly contaminated, but nonradioactive, industrial wastes to the Susquehanna River. This action was coordinated with the Office of the Governor of Pennsylvania and a press release was issued by the State [Pe80].

March 30, 1979. On this next morning, Friday, March 30, 1979, now known as "Black Friday," the most important events of the accident unfolded rapidly. Early that morning, the radiation levels being monitored above the stack of the crippled nuclear reactor were reported to the Nuclear Regulatory Commission's Harrisburg coordination center. It was relayed to the Commission's command center in Washington, D.C., where it was erroneously interpreted as an offsite reading. The Nuclear Regulatory Commission officials in Washington ordered an immediate emergency evacuation of the entire population within a 20-mile radius [TMI79a; NRC79c]. Pennsylvania Governor Thornburgh refused to accept this without better proof of the state of the emergency, and at 11:00 a.m. immediately called NRC Commissioner Joseph Hendrie, Chairman of the Nuclear Regulatory Commission, to justify the evacuation order. Chairman Hendrie never heard of the evacuation order and immediately rescinded it. However, the two men, Governor Thornburgh and Commissioner Hendrie, discussed the emergency, and

at approximately 11:30 a.m. Commissioner Hendrie suggested to Governor Thornburgh that pregnant women and preschool age children in the area within five miles of the plant site be evacuated immediately as a precautionary move [TMI79a; NRC79c; Pe80]. An on-site state of emergency was then called by Governor Thornburgh after an uncontrolled release of radiation that initial readings showed to be relatively high enough to be of concern. The Governor went on Civil Defense radio and commercial radio to warn persons from within a five to ten mile radius to stay indoors and to advise pregnant women and preschool children to leave the area immediately. The news media went into action, and prophecies were made of the dangers to health and to the reactor without any information on the status or extent of damage sustained by the reactor at that time [TMI79d; Fa81; Fa82].

March 31, 1979. President Carter was in touch with Governor Thornburgh and ordered federal assitance if needed. He also offered the same assistance to the Nuclear Regulatory Commission. The President established an interagency task force in the National Security Council to deal with the problem, the Federal Emergency Management Agency, and designated an NRC official to go directly to Three Mile Island to direct and coordinate all activities of the nuclear power plant accident. That official was Mr. Harold Denton, Director of the NRC's Office of Reactor Regulation; he arrived at the site at 2:00 p.m. with 12 additional NRC staff. Later that afternoon, Mr. John Coney, spokesman for the Pennsylvania State Emergency Management Agency, said that his office received a report from the Three Mile Island Nuclear Power Plant that there was "uncontrolled releases of radioactivity at the facility." "At this time," he continued, "we do not know the extent of that release nor do we know if it was transient or continuing. The four affected Pennsylvania counties have been notified (Dauphin, Cumberland, Lancaster and York) informing them that they should advance their state of readiness for a potential evacuation should the situation warrant [NRC79c]. This was immediately broadcast on the radio. Federal civil defense officials immediately dispatched eight evacuation specialists to Three Mile Island. Two of the evacuation specialists were assigned to each of the four counties surrounding the plant. An evacuation order never came, but by then, a few hundred thousand people living in the area had left voluntarily.

April 1, 1979. By Sunday, April 1, 1979, the situation at the nuclear power plant was coming under control, but the news media and the Washington establishment was not. Mr. Ralph Nader, in a press conference at Critical Mass, urged evacuation of residents within a 30-mile radius of the accident. Senator Gary Hart held a news conference in Washington on the Three Mile Island incident. Senator Hart then spoke on CBS's Face the Nation and said that he would introduce legislation requiring the federal government, to maintain a continuous monitoring of reactors and to assume full control immediately in the event of a crisis. The Senate Democratic leader Robert Byrd of West Virginia, said that "the Pennsylvania accident raised serious questions about the safety of nuclear power" [NRC79c]. He urged a shift toward greater reliance on coal and transferring research funds from nuclear energy to coal. President and Mrs. Carter toured the Three Mile Island nuclear plant. Both the President and his nuclear safety advisors stressed that conditions at the plant were stable [NRC79c]. The governments of France and West Germany sent scientific teams to Harrisburg to investigate the causes of the nuclear accident. Japan also

stated that it was thinking of sending a delegation. In all, 13 foreign countries sent teams, or committees to the United States to investigate the nuclear accident at Three Mile Island.

April 2, 1979. On Monday morning, April 2, 1979, NRC officials said that the hazards connected with the Three Mile Island accident were abating but that radiation levels in its containment vessel were giving federal authorities continued concern for public health [NRC79c]. According to press reports, NRC engineers believed that the status of the reactor was safe enough to permit a gradual cooldown process without risking potentially hazardous operations to speed up the cooling. NRC's Denton indicated that a complete cooldown was still days away, but declined to give a precise estimate of how long it would take.

Senator Edward Kennedy of Massachusetts called for a review of nuclear power's role in reducing United States dependence on oil imports from the Middle East and urged a fresh examination of the nuclear weapons risks arising out of the wide international use of atomic energy [NRC79c]. Senator Richard Schweiker of Pennsylvania wrote President Carter that the recent events at Three Mile Island showed that "we have seriously underestimated both the safety problems associated with nuclear-power generation and our ability to cope with a nuclear emergency" [NRC79c]. He called on the President to create a Presidential Commission to assess the full implications of the accident. According to White House Press Secretary Powell, President Carter ordered a federal inquiry into all aspects of the Pennsylvania accident [TMI79a; NRC79c]. He stated that the Nuclear Regulatory Commission as well as the Department of Energy were among agencies involved in the President's order for the Federal Study Group. On that Monday, April 2, 1979, the first working day following the confusion and emergency events of the previous Friday, voluntary evacuation and absenteeism caused unexpected labor disruption in Harrisburg, Pennsylvania. Civil defense officials said that as many as half of the 200,000 people for whom they would be responsible in an evacuation might have already left [Pe80; NRC79c].

April 3, 1979. On Tuesday, April 3, 1979, NRC spokesman Denton said the risk of a dangerous gas explosion within the damaged reactor had been eliminated. Governor Thornburgh announced that extremely low levels of radioactive iodine had been found in milk samples from 22 dairies within 18 miles of the accident. He said that monitoring of milk, water, and other products would continue and that he was "concerned about sensational reports" from the news media playing up dangers that did not exist [NRC79c].

April 4, 1979. It was not until April 4, 1979, more than one week after the accident, that NRC investigators reported that serious human, mechanical, and design errors, including a nuclear operator's improper closing of two key valves, had contributed to the Three Mile Island accident [NRC79c]. On April 5, 1979, President Carter, in his address on national energy policy, said the accident had demonstrated dramatically that the nation has other energy problems and that the accident obviously "...causes all of us concern" [NRC79c]. He said he had directed the establishment of an independent presidential commission of experts to investigate the cause of the accident and to make recommendations on how "...we can improve the safety of nuclear power plants." There will be a full accounting.

April 9, 1979. On April 9, 1979, NRC spokesman Denton declared that the crisis at Three Mile Island was over [NRC79c]. Governor Thornburgh rescinded his evacuation recommendation and said it was considered safe for pregnant women and preschool children to return to their homes within a five-mile radius of the site. The Governor also declared that all schools not already reopened would do so, that state offices would return to normal business, and that local Civil Defense forces would step down from full alert status [NRC79c; Pe80]. Governor Thornburgh in a press conference then said that he considered the uncertainties of the initial 56 hours after the accident began as the biggest single source of frustration to him [30]. Two days layer, President Carter appointed a commission to investigate the accident at Three Mile Island and to make recommendations to prevent any further accident [TMI79a]. NRC's Denton said that, despite steady progress, it may be another week before the damaged nuclear reactor at Three Mile Island can be put into safe, cold-shutdown condition, but it was not until April 20, 1979 that temperatures in the Three Mile Island nuclear reactor dropped below the boiling point for the first time since March 28, 1979 [TMI79g]. There was also a sharp drop in iodine-131 emissions from the plant by that time.

April 13, 1979. At the end of the second week of April, information was now becoming available about what went wrong in the Three Mile Island power plant. The Nuclear Regulatory Commission provided transcripts of secret Commission meetings held during the first three days of the accident to Congress. Press reports of the transcripts indicated the NRC commissioners feared a disaster in the first days, that they were operating almost totally in the blind, and that the Commission had difficulty in deciding whether or not to recommend evacuation to Governor Thornburgh [NRC79c; Pe80]. The president of the Metropolitan Edison Company, Mr. Walter Creitz, said the firm was neither prepared for the March 28th accident nor aware of its scope for two or three days; NRC's Denton said he believed the accident was caused more by human than mechanical error. He enumerated the major mistakes. At least one violated NRC rules and all involved poor judgement by the operators who were on duty. The NRC staff reported that operators of the Three Mile Island nuclear power plant inadvertently turned a minor accident into a major one because they could not tell what was really happening within the reactor. The staff said that the core could have escaped serious damage and listed at least six operator errors. HEW Secretary Califano said that radiation exposure from the Three Mile Island accident was higher than originally estimated. As a result, the statistical probability indicated that at least one to ten cancer deaths caused by radiation could be expected among the two million people living within 50 miles of the nuclear plant [Ca79].

April 26, 1979. On April 26, 1979, Governor Jerry Brown of California said the nation should give up completely on nuclear power as a future energy source rather than speed up the nuclear plant licensing procedures, as President Carter had urged. On the same day, President Carter swore in the 11 members of his Commission to investigate the accident at Three Mile Island. The Commission was headed by Dr. John G. Kemeny, the President of Dartmouth College [TMI79a].

WHAT WERE THE FINDINGS OF THE BEHAVIORAL EFFECTS TASK GROUP?

In the Charter of the President's Commission on the Accident at Three Mile Island, the Commission was given the responsibility to evaluate "the actual and potential impact of the events (of the accident) on the public health and safety and on the health and safety of the workers" [TMI79a]. Accordingly, the Public Health and Safety Task Force of the Commission set out seven objectives in its investigations---among those of greatest concern was "to assess the mental health and behavioral responses of the general population during and following the accident." The overall objective of the Behavioral Effects Task Group was to examine the effects on the mental health of the general public and the nuclear workers directly involved in the nuclear accident at Three Mile Island Nuclear Power Plant No. 2. Of particular interest were the behavioral responses of the general population and of the workers under stress during the accident. In examining effects on mental health, a distinction was made between short-term and long-term effects. Attention was also paid to the possible impact on the affected population and workers of a variety of studies, either underway or planned at that time [TMI79b; TMI79c; Ka81a; Ka81b; Br80a; Br80b; Ho80].

The Behavioral Effects Task Group comprised leading investigative psychologists, sociologists and physicians, ably assisted by a number of collaborating researchers. "Mental health" was considered a very broad topic by the Task Group, and the collection of data and limited time available for their analyses made it possible to consider only narrow aspects of the overall behavioral effects experienced. Fortunately, although narrow, these behavioral aspects---centering on measures of psychological distress, upset and demoralization---were considered important and appropriate to what was known about the most characteristic responses to stress situations [TMI79c].

The report of the Behavioral Effects Task Group was based on surveys of about 2,500 persons from four different groups: (1) The general population of male and female heads of households located within 20 miles of Three Mile Island; (2) mothers of preschool age children from the same area and similarly drawn control sample from Wilkes-Barre, Pennsylvania, which is about 90 miles away; (3) teenagers in the 7th, 9th and 11th grades from a school district within the 20-mile radius of Three Mile Island; and (4) nuclear workers employed at the Three Mile Island nuclear power plant at the time of the accident and a control group of nuclear workers from the Peach Bottom nuclear power plant about 40 miles away (TMI79c; Do79].

1. METHODS OF STUDY

The usual procedures in these psychological studies was to draw strict probability samples of households and to conduct structured, half-hour interviews by telephone [Go79; Lu77; Fr79]. Early studies of household heads immediately after the accident were conducted by mail questionnaires, and the study of the teenagers was conducted by questionnaires distributed in classrooms. All analyses were done on data collected within the first seven months immediately following the accident---from April through October 1979.

A core of similar measures of mental health, attitudes, and behavior were used in each study except for that of teenagers, which was limited to specific measures of distress developed for the study. The areas covered by measures in the other three studies were: (1) living within versus outside the five-mile radius of Three Mile Island; (2) having preschool age children in one's family; (3) recall of immediate upset at the time of the accident; (4) staying in or leaving the Three Mile Island area at the time of the accident; (5) demoralization following the accident; (6) perceived threat to physical health; (7) attitude toward continuing to live in the TMI area; (8) attitude toward nuclear power, including Three Mile Island; and (9) trust in authorities. In addition, the study of the nuclear workers included: (10) measures of their concern about the future of their occupation; and (11) their perceptions of hostility from the wider community [Ka81a; Ka81b].

In all studies, the major measures of objective threat stemming from the accident were [TMI79c]: (1) living within versus outside the five-mile radius of Three Mile Island; and (2) having preschool age children in one's family. For the workers, an added measure of objective threat was (3) whether they worked at Three Mile Island rather than Peach Bottom at the time of the accident. For teenagers, an additional measure of objective threat was (4) whether or not their families left the area during the accident, because this was a factor outside of their control.

2. THE GENERAL POPULATION AND MOTHERS OF PRESCHOOL CHILDREN

At 12:30 midday on Friday, March 30, 1979, the third day of the nuclear accident, Pennsylvania Governor Thornburgh, following telephone advice from Nuclear Regulatory Commission Chairman Hendrie advised pregnant women and preschool age children to leave the area within five miles of Three Mile Island. The governor reaffirmed this advice at a press conference later that evening---and this received wide coverage by the news media---television, radio, and the press. No comparably authoritative definition of the chief targets of threat was made prior to that time or after the governor's message. Accordingly, the two major measures of threat that were emphasized were: (1) living within five miles of Three Mile Island; and (2) having one or more preschool age children in the family. In so doing, Governor Thornburgh did not create a threatening situation; it was suggested that his statement narrowed and focused it [TMI79c].

In reviewing these important events, the main measures of mental health and behavioral effects in the studies of the general population and mothers of preschool age children centered on seven important questions: (1) How upset were people at the time of the Three Mile Island accident? (2) Who left the Three Mile Island area at the time of the accident? (3) How demoralized were people in the Three Mile Island area? (4) Was the Three Mile Island accident perceived as a threat to physical health? (5) What was the attitude after the accident toward continuing to live in the Three Mile Island area? (6) What was the attitude after the accident toward nuclear power in general, and Three Mile Island in particular? (7) Did people trust authorities---in government, in industry [TMI79c]?

How upset were people at the time of the Three Mile Island accident? On the average, people living in the 20-mile area around Three Mile Island rated the accident fairly high. Women were found to be more upset than men, and people under 65 years of age were more upset than older people. However, all groups averaged fairly high. People with a preschool age child living in the area around Three Mile Island were more upset than mothers living at a greater distance in Wilkes-Barre, Pennsylvania. In general, although people in the area found the Three Mile Island accident a relatively upsetting event no matter what their personal circumstances, the most upset were those who could infer from advice given about evacuation and safety precautions that they were in danger on two counts---living relatively close to the Three Mile Island nuclear plant and having a child in the preschool age range [TMI79c].

Who left the Three Mile Island area at the time of the accident? It was estimated that about 52% of the people living within 20 miles of the Three Mile Island nuclear power plant left the area at the time of the accident---the majority of them on Friday, March 30, 1979. More women than men, more married than nonmarried, more younger than older, and less educated than more, left the area. Some 62% of persons whose home was situated five miles or less from Three Mile Island left the area, and about 77% of people with a preschool age child in the family left. Thus, over and above differences related to personal characteristics of sex, marital status, age and education, the decision to leave was influenced by the distance of the person's home from Three Mile Island, and whether there was a preschool child in the family---presumably as a consequence of Governor Thornburgh's advice on Friday, March 30th, that preschool age children within five miles of Three Mile Island should leave the area. Of those in the general population who left, less than 5% left before Friday, March 30th, and the majority, almost 60%, left on that day. Among the 72% of mothers of preschool children who left the Three Mile Island area, almost two-thirds left on Friday, March 30th [TMI79c].

How demoralized were people in the Three Mile Island area? Demoralization is a common distress response when people find themselves in a serious predicament and can see no way out [Fr73; Do81; Li80; Do79]. Sometimes, this level of distress can approach that shown by persons suffering from mental disorders. Demoralization was far higher on the average in the population in April, 1979 closely following the accident, than in later months. About 26% of those interviewed in April showed severe demoralization. During May and later months 15% or fewer persons in the general population exhibited elevated levels. This suggests that a substantial minority, perhaps 10%, experienced severe demoralization at the time of the accident and in the 2 or 3 weeks following the accident that was directly attributable to the Three Mile Island accident itself. Levels of demoralization were higher among those living within five miles of Three Mile Island than those living at the greater 20-mile distance; men and married persons were found to have lower levels of demoralization than women and those not currently married [TMI79c].

Was the Three Mile Island accident perceived as a threat to physical health? There was uncertainty about the matter in the general population. Any perceived threat declined by April, although some uncertainty remained, and people were becoming more reassured. Women and younger people perceived more threat to their health than men or older people. Those living within five

miles of Three Mile Island, both in the general population and among mothers of young children, were less certain that their physical health was not affected by the accident than those living at a greater distance [TMI79c].

Was there a change in attitude about continuing to live in the Three Mile Island area? Did individuals devalue the area as a result of the Three Mile Island accident and would like to move away? Women held more unfavorable attitudes than men, although still, on average were favorable toward continuing to live in the area. The youngest people, in their twenties, were the least favorable; the oldest, those 75 years or older, were most favorable. All but the youngest group were generally favorable toward continuing to live in the Three Mile Island area [TMI79c].

People in the general population and mothers who had a preschool child in the family held more unfavorable attitudes toward continuing to live in the area than those without a child in this age range, but only mothers living within five miles of Three Mile Island had this attitude. Thus, only people whose attitudes were negative were those who could infer from advice given at the time of the Three Mile Island accident about evacuation and safety precautions---living relatively close to Three Mile Island and having a child in the vulnerable age range.

Were attitudes changed toward nuclear power in general, and restarting the Three Mile Island-1 and Three Mile Island-2 nuclear power plants? Women in the Three Mile Island area had more negative attitudes than men. In the general population, those with preschool age children also had more negative attitudes. Among the relatively favorable groups---men, people without preschool age children, and mothers of preschool children who were college graduates---only men had favorable rather than unfavorable attitudes toward nuclear power [TMI79c].

Did people trust authorities---federal and state officials and utility companies---following the Three Mile Island accident? In April, there was strong distrust, greater than in national pools in April and early May. The level of distrust in the Three Mile Island area declined only gradually, and distrust persisted through July and August 1979, remaining above national levels. Distrust was greater among women. It was strongest among people in their thirties, declining steadily with increasing age, and was also lower among people under 30 years of age.

The main conclusions of these psychological studies are revealing. Demoralization is a common distress response when people find themselves in a serious predicament and can see no way out [Fr73; Do79; Do81; Li80]. The amount of immediate and, fortunately, short-lived demoralization produced by the accident among household heads, in general, and mothers of preschool age children, in particular, in the Three Mile Island area should not be underestimated. The increase in demoralization at the time of, and in the month following the accident initiated on March 28th, 1979, was sharp. It was estimated that as a direct effect of the accident approximately 10% of the April general-population sample experienced demoralization as severe as that reported by persons suffering from chronic mental disorders. In the general

population, this represents elevations of measures of demoralization in psychiatrically-normal people caught in situations of extreme distress [TMI79c].

The reality of the objective stress situations in which people found themselves must be underlined. They were reacting to uncontrollable circumstances that posed a clear and major threat so far as the available information indicated. This was evident in the higher levels of demoralization shown by persons living within five miles of Three Mile Island or having preschool age children. They were told that their situation was more threatening by a respected source of information, the Governor of the State, who advised them to leave the area. Sharp elevation of demoralization in situations of severe objective threat and its rapid dissipation when the threat diminished was consistent with most of the firm findings in reactions of previously normal persons to extreme situations, such as combat during wartime and natural disasters [Fr73; Do79; Do81; Li80; TMI79c].

Although the unusually high levels of psychological demoralization apparent subsided in the general population soon after the accident, after April 1st, 1979, some of the behavioral effects of the accident did not dissipate so rapidly. People gradually became more reassured about the threat of the nuclear accident to their physical health. Distrust of authorities, however, although declining after April, remained relatively constant from May on through the summer. It was still at a level, at the end of the summer, that showed, on balance, more distrust than trust of government authorities and agencies and the electrical utility companies so far as information about and policy toward the safety of nuclear energy were concerned [TMI79c].

3. THE SEVENTH, NINTH AND ELEVENTH GRADE STUDENTS

The study of the 7th, 9th and 11th grade students in the Dauphin County School identified three main measures of threat as having potential for psychological distress and physical symptoms. Two were the same as for the general population and mothers of preschool children, viz., (1) living within five miles of the Three Mile Island nuclear power plant and (2) having one or more preschool children in the household. The third threat was whether or not they left the area during the nuclear accident [TMI79c].

In the previous study of the general population and mothers of preschool age children, the approach was to examine the factors that influenced whether or not they left the area during the accident. However, in studying the psychological effects of the nuclear accident on these adolescents, the act of leaving or staying in the area was largely a matter over which they had little influence. Therefore, the act of leaving or staying in the area was considered as an additional characteristics of the Three Mile Island accident for these young people. The question posed was whether or not temporarily leaving their homes served to increase or decrease the amount of stress these young people experienced.

The main measures of mental health and behavioral effects for these young people centered on how they felt during the accident and since the accident---worry, concern, disturbed, and anxious. They were also questioned on

experience of physical symptoms, such as sore throat or sleeping problems during the two-week period from March 29th through April 11th. These two studies provided measures of psychological distress and measures of psychosomatic distress, respectively.

In this study, the focus was primarily on contrasts in threat associated with living within five miles of Three Mile Island or further away, having preschool age siblings or not, and being in a family that left the Three Mile Island area during the crisis or in a family that stayed. Three main questions comprised the central issues: (1) How much psychological distress did these students experience during the Three Mile Island nuclear accident? (2) How distressed were the students during the six-month period following the accident? (3) Was distress accompanied by somatic symptoms [TMI79c]?

The youths studied demonstrated that there was an increase in worry, concern, disturbance, and anxiety at the time of the accident. They appeared to have reacted to the Three Mile Island nuclear accident in ways remarkably similar to the adults. They were psychologically distressed by the nuclear accident at the Three Mile Island plant. Their distress was acute during the week of the accident, but this distress diminished rapidly within two months after the accident. The assurance that came from authorities apparently helped in reducing these teenagers' psychological distress over the accident.

The student groups who experienced the highest levels of distress were those who had preschool age siblings, who lived within five miles of the Three Mile Island nuclear power plant and whose families left the area. For those who had a preschool age sibling and for those who left the area, the level of psychological distress had not dissipated after two months, but persisted at an elevated level; it had dissipated by then for the other groups. The female teenagers consistently scored higher in levels of distress during and following the Three Mile Island accident compared with male teenagers. The main conclusions to be drawn and emphasized, as in the studies of adults, is that the psychological reactions of distress were related to the realistic threat that the youngsters faced. During the accident, students in general tended to experience some psychological distress, and the distress tended to be more pronounced for students in the more threatening circumstances. These reactions tended to disappear as the threat receded in time [TMI79c].

4. THE THREE MILE ISLAND NUCLEAR WORKERS

The nuclear plant workers presented a very special group to be studied [Ka81; Ka81b]. Careful arrangements were made with officers of the appropriate unions and union leaders of the International Brotherhood of Electrical Workers so that cooperation with the workers could be established and maintained. The main measure of threat to the nuclear workers was (1) the contrast between being employed at Three Mile Island, as opposed to being employed at the Peach Bottom nuclear power plant in Pennsylvania. Note was also taken of (2) whether the Three Mile Island nuclear workers reported being at the Three Mile Island-2, the strickened nuclear plant, during the first two weeks of the accident between March 28th and April 11th. In addition, two conditions

outside the work situation included in the other studies were: (3) living within five miles of the Three Mile Island nuclear power plant, and (4) having a preschool age child in the family [TMI79c; Ka81a; Ka81b].

The main measures of mental health and behavioral effects paralleled those of the other studies, including a measure (1) of upset at the time of the accident, as well as before and following the accident; (2) of demoralization; (3) of perceived threat to physical health; and (4) questions about trust in authorities. In addition, two additional measures suited to the nuclear workers' situation were: (5) uncertainty about the future of their occupation; and (6) perception of hostility from the community. The main questions to be answered were: (1) How upset were the nuclear workers? (2) How demoralized were the workers? (3) Was the Three Mile Island accident perceived as a threat to the physical health of the nuclear workers? (4) Were the nuclear workers uncertain or insecure about the future of their occupation in nuclear power plants? (5) How hostile did the community seem to the nuclear workers? (6) Did the workers trust authorities---did they feel that information from state and federal officials was trustful, and did they think their employer kept them fully informed about risks and unhealthful conditions of their job? [Ka81a; Ka81b]

The main conclusion and one of the most important findings with regard to the nuclear plant workers was that two factors that affected the morale of the other adults and teenagers in the general population in the Three Mile Island area did not show independent effects on the morale of the workers [Ka81a; Ka81b]. These were (1) living within five miles of Three Mile Island, and (2) having preschool children in the household. Moreover, the workers did not show distrusting attitudes toward the utility company's plant authorities; there was a sharp contrast between the trust expressed by most of the workers and the distrust expressed by the general population in relation to utility companies. Clearly, therefore, the nuclear workers were not threatened in the same way as most groups in the general population. Yet, these workers at Three Mile Island, especially the large majority who were not plant supervisors, showed higher levels of demoralization during the accident and continued even after six months at higher levels than their counterparts at the Peach Bottom nuclear power plant, and than male household heads in the general population living in the Three Mile Island area. Like the Peach Bottom nuclear workers, the Three Mile Island workers believed that less than positive attitudes were held toward them by people in the wider communities; they believed the public was critical and unappreciative of their work. This belief was not unrealistic if attitudes in communities around Three Mile Island were like those reported in a national poll conducted in April 1979, within weeks following the accident, when 55% of respondents blamed the Three Mile Island nuclear plant accident on human error rather than on the government or the governmental agencies, or on the electrical power industry [TMI79c; Ka81a; Ka81b].

The salient fact was that the Three Mile Island nuclear workers' predicament of psychological distress during and following the nuclear accident had not been resolved many months later. Their level of demoralization had not returned to normal following the accident, as had been the case with other studied groups of adults in the general population living in the Three Mile Island area at that time [TMI79c].

WHAT HAVE WE LEARNED FROM THE THREE MILE ISLAND EXPERIENCE?

The conclusions that can be drawn from these studies, and from numerous parallel investigations of the health effects of the nuclear accident at Three Mile Island, were that in spite of the very serious damage to the nuclear plant, most of the radiation was contained and the actual release of radioactivity was so low that it will have a negligible effect on the physical health of individuals. The major effect of the accident was found to be mental stress in the general population and in the nuclear workers [TMI79a; TMI79c].

The President's Commission investigations found that the mental stress to which those living within the vicinity of Three Mile Island were subjected were quite severe. There were several factors that contributed to this psychological distress. Throughout the first week of the accident, there was extensive speculation---by the utility, by the government authorities, by the news media---on just how serious the accident might turn out to be. At various times, senior officials of the Nuclear Regulatory Commission and the state government were considering the possibility of a major evacuation. Some significant fraction of the population in the immediate vicinity voluntarily left the region. NRC officials contributed to the raising of anxiety in the period from Friday to Sunday, March 30th to April 1st, 1979. On Friday, a mistaken interpretation of a release of a burst of radiation from the strickened plant led some NRC officials on Friday morning to recommend immediate evacuation of the 20-mile region surrounding Three Mile Island---this would have involved over three-quarters of a million people, the entire State capitol and numerous hospitals, recovery and nursing homes, old-age homes, schools, orphanages, and prisons. On that Friday, after NRC Commissioner Hendrie rescinded that recommendation, Governor Thornburgh advised pregnant women and preschool age children living within five miles of Three Mile Island to leave the area. On Saturday and Sunday, March 31st and April 1st, other NRC officials mistakenly believed that there was imminent danger of an explosion of a hydrogen bubble within the reactor vessel, and evacuation was again a major subject of discussion. The President's Commission investigations led to the conclusion, therefore, that the most serious health effect of the accident was severe mental stress. The investigations suggest that this mental stress was short-lived. The highest levels of distress were found among those people living within five miles of Three Mile Island, in families with preschool age children, and the Three Mile Island workers [TMI79c].

However, this is far from the complete story. Much of the investigation on the psychological distress experienced could not be carried out by the Staff of the President's Commission---time and circumstances precluded the opportunity to seek the answers to many questions: What were the behavioral responses of many vulnerable groups and individuals, such as decision-makers in local and federal government in the Nuclear Regulatory Commission, and in the managing utility, in the nuclear power plant itself? What was the role of the news media---television, radio, newspapers and news magazines---how did this influence the behavioral responses and contribute to the experience of psychological distress? What impact did the behavioral responses of the general public, the nuclear workers, the managing utility, and federal and state officials, nationally and internationally, have in raising serious concerns about the safety of nuclear power [TMI79c]?

Given the time frame for the psychological research, the President's Commission's Behavioral Effects Task Group could not evaluate how long some mental health and behavioral effects would persist, nor what levels of upset, distress, and demoralization could recur should another threat appear. The time frame could not permit followup of the mental health and behavioral effects with more intensive study of the consequences to the vulnerable groups and individuals at highest risk of upset, distress and demoralization. This, however, is presently being done [Br80a; Br80b]. Moreover, a number of groups---the decision-makers, for example, and persons who left the area as a result of the accident and did not return, were not studied [TMI79c].

WHAT WAS THE ROLE OF THE NEWS MEDIA DURING AND FOLLOWING THE NUCLEAR ACCIDENT AT THREE MILE ISLAND?

One final comment concerning the role of the news media during and following the nuclear accident. The President's Commission's Task Force on the Public's Right to Information found there were serious problems with the sources of information, how this information was conveyed to the press and news media, and also with the way the press reported what it heard, or what it was told [TMI79d]. That investigation indicated there were many factors that contributed to making this nuclear accident one of the most heavily covered media events ever. Given these circumstances, the investigations suggested that the media generally attempted to give a balanced presentation which would not contribute to an escalation of panic. There were, however, a few notable examples of irresponsible news reporting and some of the visual images used in the reporting, both in the print and in the television news media, tended to be sensational [TMI79a; TMI79d].

Some members of the President's Commission did not share the conclusion that the media generally attempted to give a balanced presentation which would not contribute to an escalation of panic in the general population, in the nuclear workers, and even in decision-makers. Mrs. Anne Trunk, the housewife Commissioner from Middletown, Pennsylvania, voiced a particular point of view in her minority view in the Commission's Report [TMI79a]. She, her family, and her friends and relatives lived through the events of the accident in Middletown, Pennsylvania, some three miles from the Three Mile Island nuclear power plant. She pointed out correctly that the Commission's Report concluded: firstly, that the errors and sensationalism reported by the news media reflected confusion, ignorance, and limited information of the facts by the official sources of information; and secondly, the press and news media in general did a creditable job, one that was more reassuring than alarming, of news coverage of the event. However, some of the commissioners, scientific, engineering and legal staffs of the President's Commission argued that these conclusions of the Commission were not generally supported by the investigation reports of the events of the accident. There were, in fact, very reliable news sources available, but, overall, the news media placed too much emphasis on the "what if" scenario---What if there is a complete meltdown? What if the hydrogen bubble explodes?---rather than reporting on the "what is" situation of the reactor accident. As a result, Mrs. Trunk adds, "the public was pulled into a state of terror, of psychological stress." More than any other source of news, the evening national news reports, particularly by the major

television networks, "proved to be the most depressing, the most terrifying" [TMI79a]. To this day, the news media has not undertaken a serious self-evaluation to review their role in the Three Mile Island nuclear accident which included the events resulting in mental stress and psychological injury in the general population and the nuclear workers.

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REFERENCES

Ba79 Battist L., Buchanan J., Cogel F., Nelson C., Nelson M., Peterson H., and Rosenstein M., 1979, "Population Dose and Health Impact of the Accident of the Three Mile Island Nuclear Station," Ad Hoc Population Dose Assessment Group, Stock No. 017-001-00408-1, (Washington, DC: U.S. Government Printing Office).

BEIR80 National Research Council, 1980, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation," Report of the Committee on the Biological Effects of Ionizing Radiation, (Washington, DC: National Academy of Sciences).

Br80a Bromet E., 1980, "Preliminary Report on the Mental Health of Three Mile Island Residents," Western Psychiatric Institute and Clinic, Pittsburgh, PA.

Br80b Bromet E., 1980, "The Psychological Effects of the Accident at Three Mile Island," Presented at the 13th Annual Meeting of the Society for Epidemiological Research, Minneapolis, MN.

Ca79 Califano J., 1979, "Testimony before the Subcommittee on Health and Sceintific Research, Senate Committee on Human Resources, United States Senate," Senator Edward Kennedy, Chairman, April 4, 1979, Washington, DC.

Do81 Dohrenwend B. P., Shrout P. E., Egri G. and Mendelsohn F. S., 1981, "Measures of Nonspecific Psychological Distress and Other Dimensions of Psychopathology in the General Population," Arch Gen Psychiat, in press.

Do79 Dohrenwend B. P., 1979, "Stressful Life Events and Psychopathology: Some Issues of Theory and Method," in: Stress and Mental Disorders, (Edited by Barrett J. F., Rose R. M. and Klerman G. L.), pp. 1-15, (New York: Raven Press).

Fa81 Fabrikant J. I., 1981, "Health Effects of the Accident at Three Mile Island," Health Phys 40:151-161.

Fa82 Fabrikant J. I., 1982, "Decision-Making and Radiological Protection at Three Mile Island: Response of the Department of Health Education and Welfare," Lawrence Berkeley Laboratory Report LBL-14021, University of California.

Fl79 Flynn C. B., 1979, "Three Mile Island Telephone Survey: Preliminary Report on Procedures and Findings," Mountain West Research, Inc.

Fr73 Frank J. D., 1973, Persuasion and Healing, (Baltimore, MD: John Hopkins University Press).

Gr79 Groves R. M. and Kahn R. L., 1979, "Surveys by Telephone," (New York: Academic Press).

Ho80 Houts P. S., Miller R. W., Tokuhata G. K. and Ham K. S., 1980, "Health-Related Behavioral Impact of the Three Mile Island Nuclear Incident," Report submitted to the TMI Advisory Panel on Health Research Studies of the Pennsylvania Department of Health, Harrisburg, PA.

ICRP77 International Commission on Radiological Protection, 1977, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, (Oxford: Pergamon Press).

Ka81a Kasl S. V., Chisholm R. F. and Eskenazi B., 1981, "The Impact of the Accident at 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," Am J Public Health 71:472-483.

Ka81b Kasl S. V., Chrisholm R. F. and Eskenazi B., 1982, "The Impact of the Accident at the Three Mile Island on the Behavior and Well-Being of Nuclear Workers, Part II: Job Tension, Psychophysiological Symptoms, and Indices of Distress," Am J Public Health 71:484-495.

Li80 Link B. and Dohrenwend B. P., 1980, "Formulation of Hypotheses about the True Prevalence of Demoralization in the United States," in: Mental Illness in the United States: Epidemiological Estomates, (Edited by Dohrenwend B. P., Dohrenwend B. S., Gould M. S. et al.), Pp. 114-126, (New York: Praeger).

Lu77 Lucas W. and Adams W., 1977, "An Assessment of Telephone Survey Methods," (Santa Monica, CA: The Rand Corporation).

NRC75 Nuclear Regulatory Commission, 1975, "An Assessment of Risks in U.S. Commercial Nuclear Power Plants," Reactor Safety Study, WASH-1400, (NUREG-75/014), Washington, DC: U.S. Nuclear Regulatory Commission).

NRC79a Nuclear Regulatory Commission, 1979, "Investigation into the March 28, 1979, Three Mile Island Accident by Office of Inspection and Enforcement," NUREG-0600, (Washington, DC: U.S. Nuclear Regulatory Commission).

NRC79b Nuclear Regulatory Commission, 1979, "Title List, Publicly Available Documents, Three Mile Island Unit 2, Docket 50-320," NUREG-0568, (Washington, DC: U.S. Nuclear Regulatory Commission).

NRC79c Nuclear Regulatory Commission, 1979, "Three Mile Island: A Report to the Commission and to the Public," M. Rogovin and G. T. Rampton, Jr., (Washington, DC: U.S. Nuclear Regulatory Commission).

Pe80 Commonwealth of Pennyslvania, 1980, Report of the Governor's Commission on Three Mile Island," William Scranton III, Lt., Governor, Chairman, Harrisburg, PA.

TMI79a President's Commission on the Accident at Three Mile Island, 1979, "Report of The President's Commission on the Accident at Three Mile Island, The Need for Change: The Legacy of TMI," (Washington, DC: U.S. Government Printing Office).

TMI79b President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Public Health and Safety Task Force," (Edited by Fabrikant J. I.), No. 423 pp, (Washington, DC: U.S. Government Printing Office).

TMI79c Dohrenwend B. E., Dohrenwend B. S., Fabrikant J. I., Kasl S. V. and Warheit G. J., 1979, "Report of the Public Health and Safety Task Force on Behavioral Effects," in: Reports of the Public Health and Safety Task Force, Staff Reports to The President's Commission on the Accident at Three Mile Island, (Edited by Fabrikant J. I.), pp. 257-309, (Washington, DC: U.S. Government Printing Office).

TMI79d President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Report of the Public's Right to Information Task Force," (Edited by Ruben D. M.), (Washington, DC: U.S. Government Printing Office).

TMI79e President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Report of the Technical Assessment Task Force," Vol. I, (Edited by Jaffe L.), (Washington, DC: U.S. Government Printing Office).

TMI79f Auxier J. A., Berger C. D., Eisenhauer C. M., Gesell T. F., Jones A. R. and Masterson M. E., 1979, "Report of the Public Health and Safety Task Force on Health Physics and Dosimetry," in: Reports of the Public Health and Safety Task Force, Staff Reports to the President's Commission on the Accident at Three Mile Island (Edited by Fabrikant J. I.), pp. 35-194, (Washington, DC: U.S. Government Printing Office).

TMI79g President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Technical Assessment Task Force," Vol. II, (Edited by Jaffe L.), (Washington, DC: U.S. Government Printing Office).

TMI79h President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Technical Assessment Task Force," Vol. III, (Edited by Jaffe L.), (Washington, DC: U.S. Government Printing Office).

TMI79i President's Commission on the Accident at Three Mile Island, 1979, "Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Technical Assessment Task Force," Vol. IV, (Edited by Jaffe L.), (Washington, DC: U.S. Government Printing Office).

TMI79j Axelrod D., BLuestone M., Densen P. M., Fabrikant J. I., Fowinkle E. W., Johnson K. G., Jones E. W. and Selser R., 1979, "Report of the Public Health and Safety Task Forkce on Public Health and Epidemiology," in: Staff Reports to The President's Commission on the Accident of Three Mile Island: Reports of the Public Health and Safety Task Force, (Edited by Fabrikant J. I.), pp. 311-423, (Washington, DC: U.S. Government Printing Office).

TMI79k Abrahamson S., Bair W. J., Bender M. A., Bloom A. D., Bond V. P., Casarett G. W. and Fabrikant J. I., 1979, "Report of the Public Health and Safety Task Force on Radiation Health Effects," in: Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Public Health and Safety Task Force, (Edited by Fabrikant J. I.), pp. 195-256, (Washington, DC: U.S. Government Printing Office).

TMI79l Fabrikant J. I., 1979, "Report of the Summary of Public Health and Safety," in: Staff Reports to The President's Commission on the Accident at Three Mile Island, Reports of the Public Health and Safety Task Force, (Edited by Fabrikant J. I.), pp. No. 1-34, (Washington, DC: U.S. Government Printing Office).

Wa79 Washington Post, April 3rd, 1979, Washington, DC.

We79 Weinberg A. M., 1979, "Salvaging the Atomic Age," Wilson Quarterly, III:88-115.

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