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My training is in respiratory care and in the care of the critically ill, particularly in the area of mechanical ventilation of patients in acute respiratory failure. I received an Associate in Letters, Arts and Sciences from the Pennsylvania State University in 1975 and a Bachelors in Health Care and Administration from Ottawa University in 1981. I received my training in respiratory care at the Advanced Respiratory Therapy Program at the University of Chicago Hospitals and Clinics in 1978. I also attended Advanced programs at Tufts University and at Georgia State University. I am currently both Certified and Registered by the National Board for Respiratory Therapy. I am a member of the American Association for Respiratory Therapy and of The Society of Critical Care Medicine.

My paper "Hospital organizational response to the nuclear accident at Three Mile Island: Implications for future-oriented disaster planning" American Journal of Public Health March, 1982, is attached to this written testimony. The paper was prepared following the 1979 incident to illustrate the lack of medical preparation for area-wide evacuation. The paper describes organizational response of the four closest hospitals to the plant. The paper also makes recommendations for future planning efforts. During the TMI incident I was inside the 10 mile risk zone and had the opportunity to observe disaster response and the preparation of crash plans for the movement of institutionalized patients.

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## Hospital Organizational Response to the Nuclear Accident at Three Mile Island: Implications for Future-Oriented Disaster Planning

CHRISTOPHER MAXWELL, BA, RRT

**Abstract:** The 1979 nuclear accident at Three Mile Island (TMI) near Harrisburg, Pennsylvania, caused severe organizational problems for neighboring health care institutions. Dauphin County, just north of TMI, contained four hospitals ranging in distance from 9.5 to 13.5 miles from the stricken plant. Crash plans put into effect within 48 hours of the initial incident successfully reduced hospital census to below 50 per cent of

capacity, but retained bedridden and critically ill patients within the risk-zone. No plans existed for area-wide evacuation of hospitalized patients. Future-oriented disaster planning should include resource files of host institution bed capacity and transportation capabilities for the crash evacuation of hospitalized patients during non-traditional disasters. (*Am J Public Health* 1982; 72:275-279.)

### Introduction

From March 28 to April 4, 1979, the nuclear accident at Three Mile Island (TMI) caused particular stress on the surrounding health care system and found it ill prepared to deal with community-wide evacuation. Area hospitals found existing disaster plans inadequate and developed evacuation plans both spontaneously and in concert with local emergency management agencies. Crash planning was hampered by the technical complexity of the accident and by conflicting information from the media, from TMI, and from the Nuclear Regulatory Commission (NRC). During the first three days, governmental direction to hospitals was very limited (undoubtedly due to the lack of a precedent); however, at the height of the crisis, 150 governmental agencies participated in ad hoc emergency activities. Following a meeting with local emergency management officials 48 hours after the initial release of radioactive material from TMI, area hospitals developed both coordinated and individualized response strategies.

At TMI, the emergency measures required by the NRC as part of its licensing procedure included an emergency

response plan involving the area within a two mile radius surrounding the plant. The county to be discussed (Dauphin) had an evacuation plan (updated in 1978) that included a five mile radius around TMI. This area contained three nursing homes and no hospitals. As evacuation plans were expanded during the incident, the five mile radius was increased to 20 miles, which included 14 hospitals and 62 nursing homes.

Hospital disaster plans generally include the management of an influx of trauma cases and provide for the limited emergency evacuation of patients. A flood, conflagration, or bomb threat can result in the transfer of patients and the short-term curtailment of operations. The evacuation of a hospital, however, is very rare, and has been an event restricted to a limited area. Hospital organizational response to the nuclear accident at TMI provides an opportunity to review disaster planning—planning that, after TMI, can no longer be restricted to fire, flood, and trauma. Hospitals must now include the possibility of area-wide evacuation of facilities and must plan for the transportation of bed ridden and critically ill patients to host institutions during area-wide emergencies.

### Dauphin County Hospitals

Dauphin County (see Figure 1) contains four hospitals that were in the immediate risk zone. Located in Hershey, the Milton S. Hershey Medical Center of the Pennsylvania State University (HMC) was the closest to TMI (9.5 miles NNE). Community General Osteopathic Hospital (CGOH) (10.0 miles NNW); Harrisburg Hospital (HH) (10.5 miles

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**Editor's Note:** See also related editorial p 237 this issue.

COMMENTARY

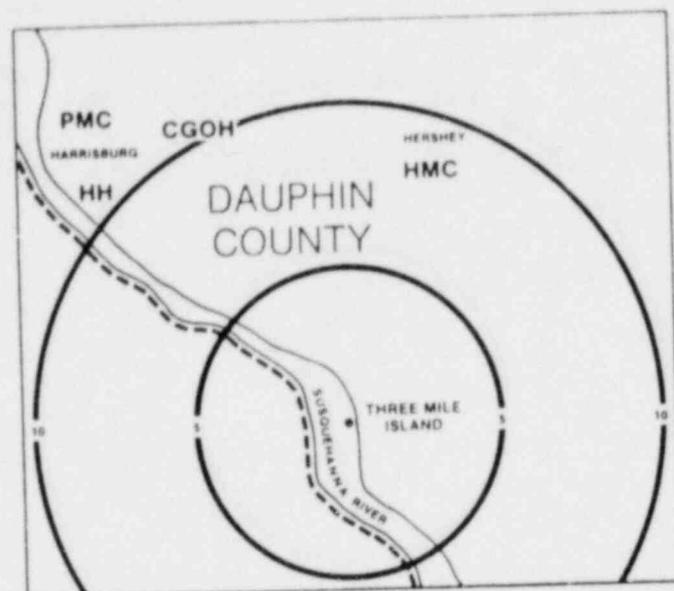


FIGURE 1—Distance from and Location of Dauphin County Hospitals from TMI

NW); and Polyclinic Medical Center (PMC) (13.5 miles NW) are all located in greater Harrisburg. The combined bed capacity of these four hospitals is 1,561.

The author considers information from these hospitals to be representative of disaster planning during the accident. The time frame of the acute phase is March 28 to April 2, 1979. Recovery from the incident is generally considered to have begun April 4. Hospital organizational response may be divided into five categories: census reduction, staffing, administrative response, emergency/critical care services, and hospital evacuation and transportation.

### Census Reduction

All area hospitals adopted a common strategy to cope with impending evacuation. The primary strategy—the discharge of ambulatory and stable patients to the care of their immediate families—quickly reduced the area-wide census from an average of 80 per cent to less than 50 per cent of capacity.<sup>1,2</sup> The discharge of ambulatory patients also freed hospitals to treat potential victims of radiation.<sup>3</sup> Hospital

census figures (March 28–April 2, 1979) are detailed in Table 1. Estimates of concurrent area-wide spontaneous evacuation vary from 20–35 per cent<sup>4</sup> to 39 per cent<sup>4</sup> of the total population; by March 31, more than 200,000 people had fled the area.<sup>5</sup>

Other strategies to reduce inpatient census included the cancellation of all but emergency surgery and the restriction of admissions to life-threatening emergencies. Together these methods allowed hospitals to stabilize their census at a manageable level should total evacuation have become necessary. It is important to note that those patients retained in the hospitals were unable to be easily moved or were in critical condition, including those at all hospitals requiring life support systems in Intensive Care Units.

### Staffing

Predictably, the conflicting responsibilities to family and to work resulted in escalating staffing problems as the crisis continued. Nursing and ancillary support staff who had young children felt considerable pressure as it became evident that the problem at TMI was unlikely to be resolved quickly.<sup>6</sup> Many elected to leave the area to protect their families. Some workers and managers moved family members to points outside the risk zone and then returned to the hospital for extended periods of time. The calculated discharge of ambulatory patients to their families decreased the need for full staffing and this, in conjunction with scheduled reduced weekend staffing, allowed many nursing and technical staff members to leave the area. However, by the fourth day of the incident, some hospitals were forced to consolidate remaining patient units. One institution offered overtime pay for any hourly rated employee working March 30 through April 3. The staffing crisis was not restricted to professional or technical staff. Physician staffing reached critical levels at at least one institution, with one Emergency Department physician noting that only six of more than 70 doctors remained available.<sup>7</sup>

HMC experienced the potential exposure of medical students to radiation during the crisis. Students in the medical and health professions have, in the past, proven to be valuable assets during disasters; however, they were a cause of considerable controversy during the TMI incident. HMC's DeMuth noted the "grave concerns" of the medical school teaching faculty toward the encouragement of medi-

TABLE 1—Hospital Census Change during Acute Phase March 28–April 2, 1979

Hospital	Capacity	Distance and Direction from TMI	Census		
			March 28	April 2	% change
Hershey Medical Center	350	9.5 mi. NE	300	87	-71
Community General Osteopathic Hospital	176	10.0 mi. NNW	148	62	-58
Harrisburg Hospital	479	10.5 mi. NW	405	259	-36
Polyclinic Medical Center	556	13.5 mi. NW	537	393	-27

cal students to remain at the medical center.<sup>5</sup> Another source notes the anxiety of the medical students.<sup>6</sup>

Following the accident, the unusual nature of the emergency was taken into account, and no hourly rated employee was penalized for being absent (although the use of vacation pay for unscheduled absences was frequently denied). There was, however, at least one management-level termination due to absence during the incident.

### Administrative Response

On the third day of the incident, communication was established between hospital administrators and local emergency management agencies. All hospitals immediately began categorizing patients for possible discharge. The administrative response at one institution (CGOH) involved a centralized command (Hospital President) and the following delegations: patient discharge evaluation (Director of Patient Care), maintenance of patient/hospital records (Director of Finance), patient transportation (Director of Personnel), medical support and evacuation supplies (Medical Director), and facilities security (Director of General Services).

At all area hospitals the charts of remaining patients were color-coded as follows to facilitate emergency transportation:

Red	→ Discharge
Blue	→ Ambulance
Blue/Black	→ Ambulance with monitor/respirator
Yellow	→ Bus
Green	→ Flat-bed trailer

A problem shared by most institutions—the inadequacy of telephone communications—had been recognized well before the TMI incident.<sup>8</sup> HMC experienced a failure of the entire telephone system that was reported to have lasted as long as ten hours.<sup>9</sup> Experience at TMI also revealed that emergency radio communications carry two significant risks: 1) governmental radio communications at the State Capitol interfered with the Dauphin County computer system, and 2) radio channels are accessible to the general public.<sup>1</sup> Area hospital administrators had been guaranteed advance notice of impending general evacuation: this plan was discarded when emergency management officials realized that the plans had been overheard by citizen radio operators, and were therefore likely to fail.<sup>1</sup> Hospitals were thus faced with the dilemma of delaying evacuation until the last minute or risk early evacuation and the resulting area panic.

### Emergency/Critical Care Services

HMC was under contract to TMI to receive and treat all radiation-contaminated workers. In the absence of communications, however, the injured would have arrived "completely by surprise."<sup>10</sup> HMC facilities included a one-room

radiation treatment center located in the radiology department; plans were later formulated for the treatment of 75–100 injured per hour in the tunnel of an underground receiving area.<sup>9</sup> HMC also opened an evacuation center at the Hershey Sports Arena, and prepared for up to 5,000 arrivals. HMC and PMC were designated by the Dauphin County Office of Emergency Preparedness as the last emergency rooms in the area to provide medical care in a graduated shutdown; however, one source later reported that last minute services were to be provided by HMC and HH.<sup>10</sup>

DeMuth noted that perhaps most crucial to the provision of emergency/critical care services was the turnaround in physician philosophy required to deal with the accident.<sup>1</sup> Hospitals are accustomed to putting the critically ill at the highest priority. In previous disasters requiring evacuation the critically ill have been the first to be transferred.<sup>11</sup> During the TMI incident, hospitals evacuated the maximum number of stable patients first; the critically ill were left until last, some maintained on life-support and cardiac monitoring systems, or on oxygen support at all hospitals (see Table 2).

### Hospital Evacuation and Transportation

Although the official governmental stand was that there was no general evacuation (other than the short-lived Governor's Advisory for pregnant women and preschool children within a five mile radius of TMI), hospitals were indeed planning for an eventual evacuation effort. While local agencies compiled a list of host counties and institutions and monitored their census, individual hospitals made their own contacts and arrangements. Two recorded incidents of medical evacuation occurred: three nursing homes within the five mile radius moved their patients by ambulance on the night of March 30, and HMC transferred three neonates that were on life-support systems to the Childrens' Hospital of Philadelphia on March 31. CGOH made arrangements with the

TABLE 2—Number of Patients Maintained on Mechanical Ventilatory Support and Oxygen Therapy from March 28 to April 2, 1979

Hospital	Number of Patients on Mechanical Ventilatory Support	Number of patients on O <sub>2</sub> Therapy
Hershey Medical Center	3 → 0 (Neonatal)	17
Community General Hospital	6 → 4 (Adult)	
Harrisburg Hospital	2 → 3 (Adult)	16
Harrisburg Hospital	3 (Adult)	46
Polyclinic Medical Center	4 (Adult)	38
	3 (Neonatal)	

Philadelphia College of Osteopathic Medicine, 100 miles SE of Harrisburg, to accept all of its patients in the event of a rapid and final evacuation.

In addition to the use of family vehicles and ambulances, projected medical facility transportation also included flat-bed trailers and helicopters. The Pennsylvania State Police and the Army National Guard based at nearby Fort Indiantown Gap planned to use Jet Rangers, Huey and Chinook helicopters. The State Police listed eight and the Army National Guard 39 available aircraft.<sup>12</sup> Evacuation of non-ambulatory patients by trailer or by air would have taken place under truly emergent conditions and, thus, would have been hazardous to both patients and staff.

To deal with an expanding risk zone, emergency management officials planned to evacuate the population in radial directions away from TMI.<sup>2</sup> Some surrounding counties, however, also planned to block access to some highways to control entry into their municipalities.<sup>1</sup> Dauphin County evacuation routes were due North<sup>1</sup>; however, HMC moved and CGOH planned to move patients SE to Philadelphia. Evacuation plans for the county were published in the Harrisburg *Patriot News*—six days after the initial release.

### Key Problems and Recommendations

1. The overloading of telephone circuits noted in previous disasters<sup>8</sup> and in the TMI incident (2,000,000 calls were placed on circuits designed for half that number<sup>4</sup>), demonstrate the need to improve area-wide communications systems. A centralized command should integrate area needs with available resources.<sup>2</sup> Hospital communications must be linked to designated emergency operations centers. Channels of communication and hospital disaster response must be tested at frequent intervals to reveal potential inadequacies.

2. Further study is needed into the roles of public health officials, both physician and allied health personnel, during nontraditional disasters. Gordon MacLeod, then Secretary of the Pennsylvania Department of Health, noted the absence of strong input by public health physicians into most operational decisions made during the TMI incident.<sup>13</sup> Three factors should be addressed: public health physicians need training in the health aspects of radiation contaminated environments, and in area-wide evacuation planning, and emergency decisions made by nuclear engineers should be supplemented by medical advice.

3. Potassium Iodide, a thyroid blocking agent to prevent tissue uptake of radioactive iodine-131, was not available for immediate distribution to the involved population during the accident at TMI.<sup>1,4,14</sup> Governmental agencies and private corporations frantically arranged for emergency production and shipment of the drug to Harrisburg. It arrived four days after the initial release from TMI. This experience suggests that in areas of risk, hospitals and other institutions should consider stockpiling supplies of potassium iodide for administration to those who cannot be rapidly evacuated.

4. Hospital administrators should develop contingency staffing plans and should analyze methods of graduated

discharge, patient categorization, and patient-unit consolidation. Administrators can expect significant absences from staff members who have family responsibilities and should anticipate a shortage of physicians. Employee call-in systems, designated responsibilities, and a planned, structural response may allow hospitals to stabilize operations until the immediate crisis is resolved. Long-term crises, however, will require governmental personnel back-up from many agencies and will probably require medical support and transportation assistance.

5. Mass medical evacuation and transportation systems are difficult to arrange *during* a crash response to an emergency and, therefore, are worthy of immediate study by all hospitals. Response should not be restricted to planning for accidents at nuclear-generating facilities, but should cover a wide range of situations. Emergency Medical Systems, until now accustomed to getting patients *into* acute care facilities, should plan responses to disasters causing influx, evacuation, and combined influx and evacuation. Inventories of area transportation capabilities and host institutions should be readily available to all hospitals.

### Summary

Traditional disasters have included fire, flood, storm, and trauma. Virtually all external events are preceded by a warning and by community activation.<sup>11</sup> Nontraditional disasters may include nuclear power plant accidents such as at TMI, nuclear weapons accidents, toxic waste accidents, terrorist attacks, or other phenomena without historical precedent.<sup>1</sup> In contrast to traditional disasters, all are marked by the lack of a warning phase, and may involve hospitals immediately. Nuclear power plant accidents are further characterized by the lack of clearly defined limits of both time and space—nuclear accidents can escalate rapidly and may involve a continually expanding risk zone. Future-oriented disaster planning should prepare hospitals to deal with a wide variety of situations, including those which may necessitate area-wide evacuation.

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Material reviewed includes

- A. Attachment I, General Evacuation Procedures, Westchester County RERP, Department of Health (including SF 15-17).
- B. Responsibility - Public Health and Sanitation Services, Section III, C-6
- C. Responsibility - Accident Assessment, Section III, C-14
- D. Responsibility - Protective Response Evaluation, Section III, C-15
- E. Responsibility - Radiological Exposure Control, Section III, C-16
- F. Testimony, Daniel Hyman, M.D., Commissioner of Health, Rockland County, Nuclear Regulatory Commission Hearings on Indian Point.

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Based on this limited information only, my assessment/recommendations are as follows:

Medical facility response to nuclear accidents should be classified as

<u>Class</u>	<u>Medical Facility Status</u>
I	Normal
II	Standby
III	Alert

The Lead Emergency Management Agency should order the following medical facility response:

- A. Class I - notify appropriate medical facilities of the possible need for decontamination procedures
- B. Class II and III - notify medical facilities of situation at power plant
- C. Obtain current census/transportation needs assessment
- D. Notify predesignated relocation hospitals
- E. Determine beds available in host area
- F. Establish medical transportation staging areas
- G. Name staging coordinator
- H. Establish radio communications between staging area and emergency management agency
- I. Determine staffing requirements of medical facilities in risk area
- J. Request medical support if necessary
- K. Color code charts by predetermined system for transportation needs (e.g. car/bus/ambulance/trailer/air)
- L. Establish evacuation triage ranking as follows:

(L. Establish evacuation triage ranking as follows:) - continued

(First) - Maternity  
Pediatrics  
Neonates  
Medical/Surgical  
Intermediate

(Last) - Critically ill

M. Class III (Only)

1. Discharge to family where possible/appropriate
2. Discontinue surgery/admissions
3. Restrict non-emergency admissions
4. Consolidate remaining patients
5. ? distribute ki to remaining staff/patients
6. Maintain sheltering precautions (windows/air intake, etc.)
7. Maintain hospital emergency room until directed to close by lead agency
8. Emergency management agency designate remaining area-wide emergency facility

Other considerations include

- A. Five mile audible warning system
- B. Prepared EBS warnings/instructions
- C. Evacuation routes for public dissemination
- D. Destinations/mass care centers
- E. Inventories of risk facilities/census
- F. Inventories of host facilities/census
- G. Inventories of heliport location/telephone numbers
- H. Ambulance service capabilities for 5, 10, 20 mile radius and statewide
- I. Air medical evacuation/landing capabilities
- J. 360 degrees evacuation plans
- K. Estimated time for population evacuation
- L. Inventories of homebound
- M. Liason with - medical society  
- state hospital association