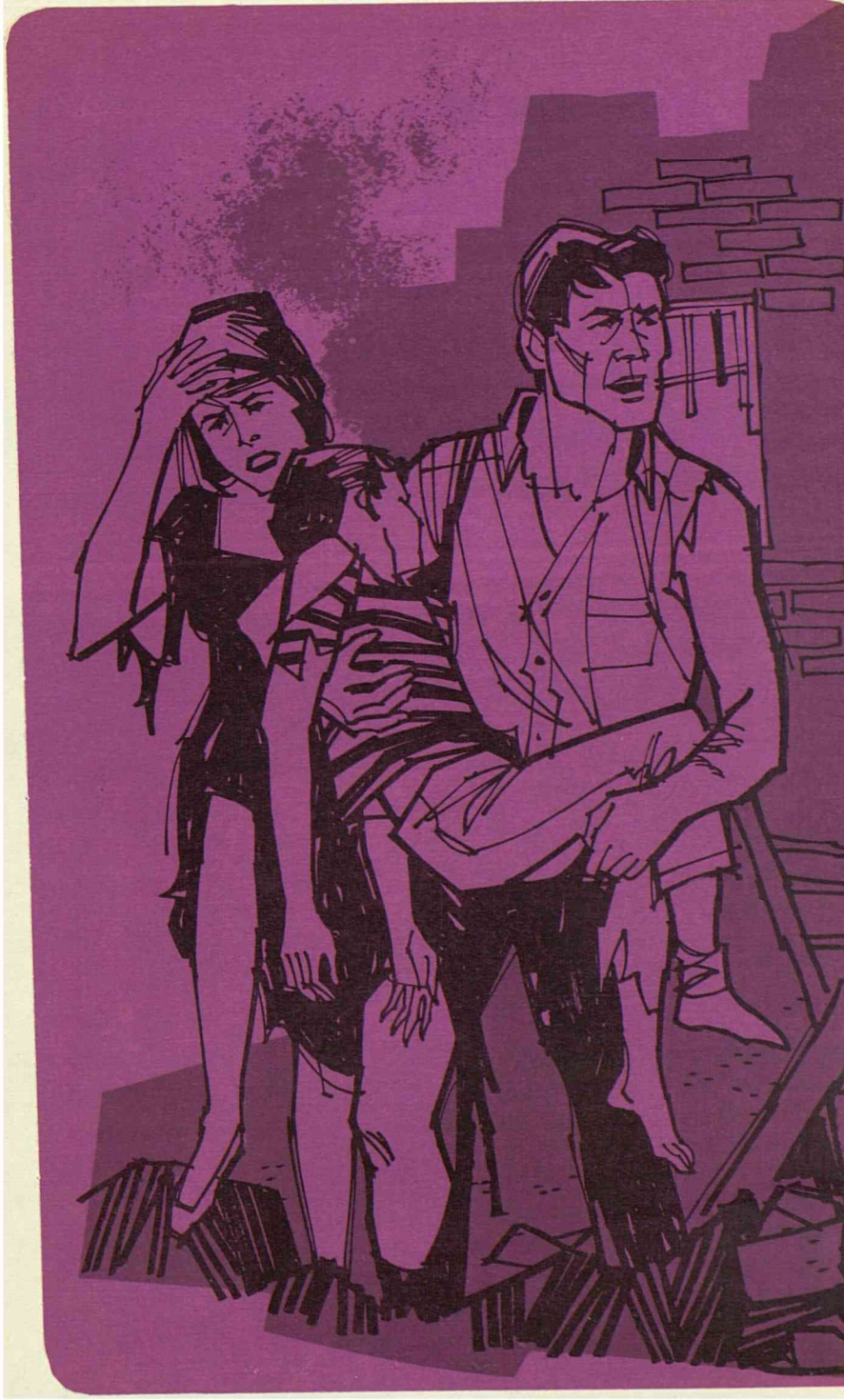

a mobile medical facility for emergency disaster relief

architecture 422 · thesis program
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december 11, 1973
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Serious disasters have occurred throughout the history of man. At times, they were the result of wars between various groups of people, but just as often disasters have occurred from what could be termed natural causes. These would include hurricanes, tornadoes, floods, earthquakes, volcanic eruptions, etc. During the past century alone, 9 million people died in floods, 900,000 in earthquakes, and more than 600,000 in hurricanes, typhoons, and cyclones.[1] In the 20th century alone, there have been 26 natural disasters, each with 10,000 or more victims, as shown in Figure 1.[2] Along with these disasters, which can be termed major, are hundreds and thousands of smaller disasters occurring every year. Victims of natural disasters alone already number several million in this century.[3]

Losses in these disasters not only include human life but also extensive damage. The two do not necessarily relate directly, however. For example, the San Francisco earthquake in 1906 killed (directly or indirectly) 600 persons, with $524 million lost in property damage. It is estimated that some amount of

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[1] E. K. Kroger, "Proposal for an International Disaster Center," Health Services Report, Jan. 1973, p. 23.

[2] Kroger, p. 25.

[3] Kroger, p. 24.

major disasters of the 20th century

Table 2. Most serious natural disasters of 20th century

Year and reference No.	Kind of disaster	Place	Deaths
1902 (*2,10*)	Eruption....	Mt. Pelee, West Indies.	40,000
1908 (*2,6*)	Earthquake..	Messina, Italy.....	80,000
1911 (*8*)	Flood.....	Yangtze Kiang, China.	100,000
1920 (*2,5*)	Earthquake..	Kansu, China.....	180,000
1923 (*11*)	Earthquake..	Tokyo, Japan.....	143,000
1927 (*8*)	Earthquake..	Narha, China.....	200,000
1931 (*12*)	Flood.....	Hoangho, China....	1,000,000
1932 (*1*)	Earthquake..	Kansu, China.....	70,000
1935 (*2*)	Cyclone.....	India and Pakistan..	60,000
1939 (*2*)	Earthquake..	Chile.....	40,000
1939 (*8*)	Typhoon....	Trentin, China.....	200,000
1939 (*1*)	Earthquake..	Turkey.....	33,000
1942 (*8*)	Flood.....	India and Pakistan..	10,000
1949 (*8*)	Flood.....	Guatemala.....	40,000
1950 (*2*)	Earthquake..	Assam, India.....	26,000
1959 (*8*)	Flood.....	China.....	2,000,000
1960 (*2*)	Earthquake..	Chile.....	10,000
1960 (*2*)	Earthquake..	Agadir, Morocco...	12,000
1960 (*18*)	Cyclone.....	East Pakistan.....	15,000
1961 (*18*)	Cyclone.....	East Pakistan.....	12,000
1962 (*2*)	Earthquake..	Iran.....	10,000
1963 (*18*)	Cyclone.....	East Pakistan.....	12,000
1965 (*18*)	Cyclone.....	East Pakistan.....	20,000
1966 (*18*)	Cyclone.....	East Pakistan.....	15,000
1968 (*1*)	Earthquake..	Iran.....	12,000
1970 (*17*)	Earthquake..	Peru.....	70,000
1970 (*18*)	Cyclone.....	East Pakistan.....	206,000

fig. 1

damage occurred in the 1971 earthquake in Peru, which caused 70,000 deaths and thousands upon thousands of injuries.[4]

Certain areas of the world are particularly prone to major disasters for geological or geographical reasons. Along with these reasons it appears that certain weather conditions tend to relate to certain areas. In mapping major world disasters, certain regional patterns seem to develop as indicated in Figure 2.

In past years the most serious natural disasters have struck underdeveloped countries or areas with a weak infrastructure. These areas usually contain large masses of people in overcrowded conditions. In most of these disasters the authorities were incapable of dealing with the situation and therefore through inefficiency contributed to the number of deaths (people who might have been saved had they been helped earlier).

The major problem in such cases is the lack of leadership which understands the situation fully and which has the ability to coordinate and organize all relief efforts.[5] In the past, aid has been sent by independent groups or countries, often with the intention of receiving something in compensation for the aid.

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[4]Kroger, p. 24.

[5]Kroger, p. 24.

areas of major natural * disaster concentration

fig. 2

*volcanoes, floods, earthquakes, hurricanes

On the other hand, Dr. Kroger points out that both of these organizations already have certain built-in inadequacies which might hamper an international disaster center of this nature. He concludes that the most suitable solution is to create an independent international organization supported by both the United Nations and the International Red Cross, as well as by other individual government and organizations. If such a system proved unfeasible, the disaster center might be attached to the United Nations in the same manner that the U.N. High Commission for Refugees is attached.[7] This would afford it some independence for immediate assistance. However, because the U.N. is chiefly a political organization and all countries are not members, the former would be the better system.

As proposed by Dr. Kroger, the staff for an international center could be obtained through a type of leasing system from the various international organizations--International Red Cross, World Health Organization, Food and Agricultural Organization, World Meterological Organization and from the U.N. disaster assistance program. All of these organizations have emergency funds which could be tapped to organize the system. With support from only international organizations, the center would be less politically influenced.[8]

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[7]Kroger, p. 26.

[8]Kroger, p. 27.

The system would operate from a central office (possibly located in Geneva, Switzerland) and would be further broadened by the addition of regional offices throughout the world.

The responsibility of the center would be to advise, coordinate, and organize all international aid in disaster situations. Of prime importance would be a filing system showing where and how quickly transportation, teams of specialists, and relief supplies could be provided to a disaster site.

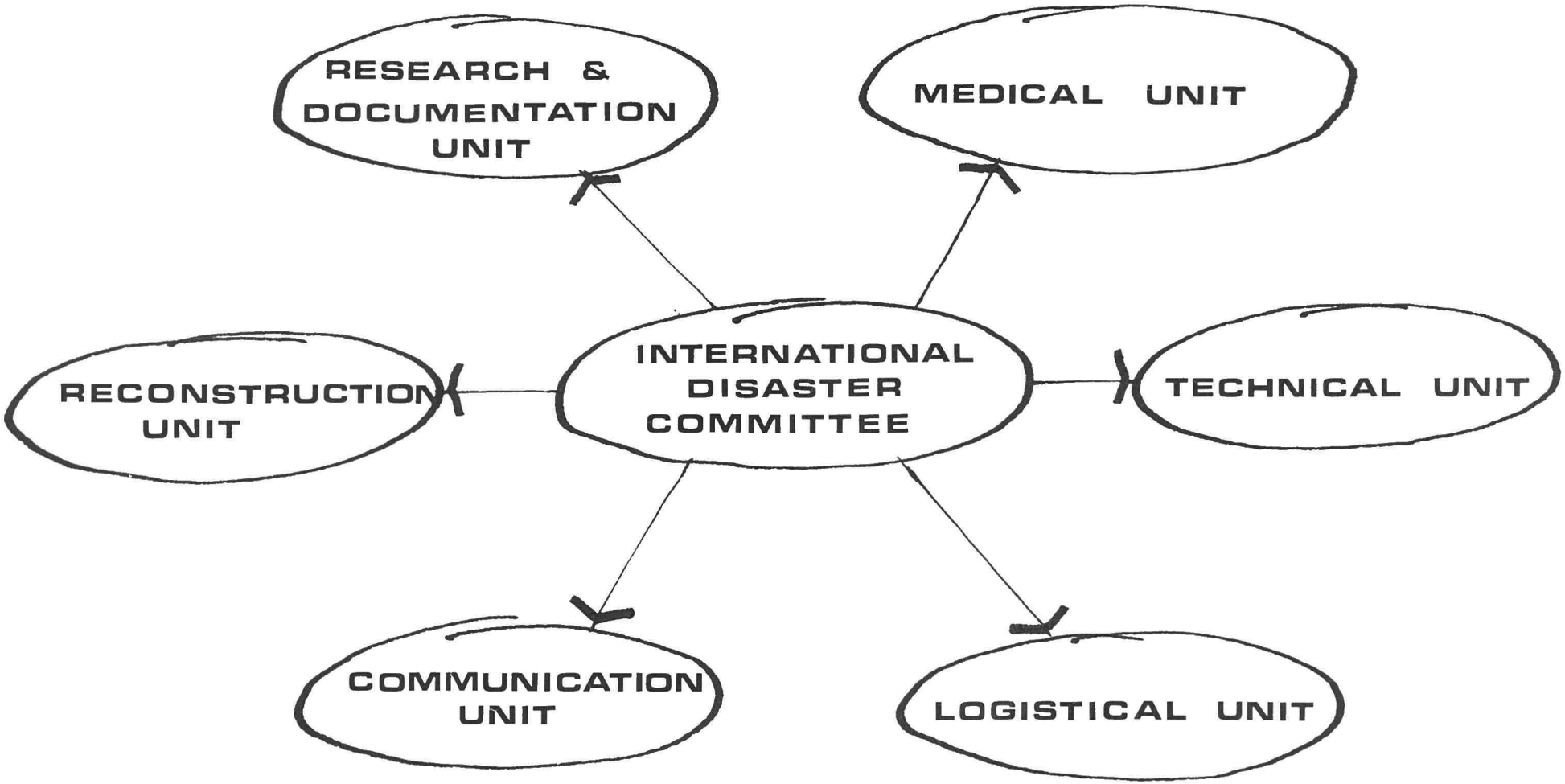
Dr. Kroger offers the following organizational diagram (Figure 3) to show what the system would encompass. The following is a description of these units.

Technical unit: organization of the immediate rescue of survivors; clearing roads and other transport lines; the provision of emergency housing.

Logistical unit: calculation of vital relief necessary per capita and per unit of territory for the different countries and for the different types of disasters; organization of required transportation.

Communications unit: establishment of communications link between the disaster area and the international center; set-up of an immediate network of communications within the disaster site.

Reconstruction unit: help in planning reconstruction; find means of obtaining funds for a reconstruction program; installation of a disaster warning system.



international disaster organization

fig. 3

Research and Documentation unit: complete documentation of the disaster and an evaluation of past disasters to help improve the response in future disasters; collection of precise records from each country.

Medical: provision of emergency care for the seriously injured; vaccinations and control of sanitary conditions to prevent outbreaks of disease; establishment of medical and public health relief teams in advanced countries on constant standby for foreign missions; providing social and psychological assistance.[9]

Thesis Proposal

The medical unit is the one which will be dealt with in establishing a Mobile Emergency Medical Facility For Disaster Relief. The hope is to produce a feasible system of facilities which can be on constant standby in the event of a disaster and easily transported to the scene and put into operation. Depending upon the situation, the unit could supplement existing medical facilities or in other cases where no medical facilities were operational, could function as an independent center.

In the event of disaster a regional team of experts in the medical, tech-

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[9]Kroger, p. 27.

nical, logistical, and communications fields would immediately travel to the site and assess the problems and needs. After the assessment, organization and relief would follow.

Each country would have to select representatives to cooperate with the regional disaster center. These experts, once notified, would leave immediately for the site by their own means of transport. Within 24 hours, relief efforts would be underway.[10]

The first effort would be to establish a central disaster office through which all relief would be channelled. Depending upon the extent of damage and casualties other experts and facilities could be brought in to supplement those already operating. With adequate preparation, the first relief would arrive during the first 24-48 hours. For assistance during the primary emergency period, goods, facilities, and personnel would be air-dropped.

The central disaster office would provide a filter for the coordination of all incoming aid and would prevent ourpluses of aid (which have been known to occur).

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[10] Kroger, p. 29.

Situations to which the disaster unit would respond are as follows:

1. A situation in which the number of live casualties to be handled is above 50/60.

2. A situation which would necessitate the dispatch of one or more mobile medical facilities and teams to the scene.

3. A situation in which existing medical facilities (hospitals have been incapacitaged.

After communicating with and determining local inadequacies, it would be the responsibility of the experts within the regional centers to evaluate what type and how much aid should be sent. If the disaster is of a small enough scale to be handled more easily by local aid, the regional centers will provide only a coordination vehicle.

The role of an international disaster center in armed conflict or civil disturbance would create certain problems which would have to be dealt with in other ways.

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[11] James Fairley, "Mass Disaster Schemes," British Medical Journal, Nov. 1969, p. 552.

background

general
medical

The Nature of Disasters: General

The term "disaster" evokes many differing images to the individual. At one extreme, an individual may be the involved party, and at the other extreme an entire party, and at the other extreme an entire community or nation may be affected.

Allen H. Barton defines disaster as a "large unfavorable change in the inputs of some social system."[12] Within this large category could be placed such events as hurricanes, earthquakes, tornadoes, race riots, epidemics, depressions, bombings, drought, and urban decay. There seems to be a wide variety of causal agents, but nevertheless they all exhibit definite similarities.

Unfortunately, the word "disaster" has taken on a number of different meanings throughout the world. The word is often used in describing the disaster agent (earthquake, tornado, etc.). Disaster also is used to mean the physical impact derived from the agent (the damage to life and property). The word has also been used to describe the evaluation of the physical event.

Although it may not at first seem important to differentiate between the various uses of the word "disaster," it can be seen that what may be considered

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[12] Russell Dynes, Organized Behavior in Disaster, New York: Heath Lexington Books, 1970), p. 5.

a disaster in one community will not be considered as such in another area.

Disaster agents are characterized as follows:

1. They differ in frequency - certain areas are more prone to certain disasters than other areas (eg. communitities on the southeastern and Gulf Coast are more prone to have hurricanes).

2. They differ in predictability - disasters caused by weather conditions at times are more predictable than are other conditions such as earthquakes or volcanoes.

3. They differ in controllability - technological advances have provided the opportunity to change certain conditions which might lead to disaster (eg. disasters caused by weather conditions). Other agents are not as easily controlled. Earthquakes, for example, are uncontrollable at the present time, although some damage controllability can be achieved by figuring earthquake loads in the structural calculations of buildings.

4. They differ as to their cause - an important distinction must be made between man made and natural disasters. Sociologists have noted that in the event of natural disaster, a heightened concern is expressed for others similarly affected. On the other hand, in man-made disasters a considerable amount

of resentment is directed toward those who presumably caused the disaster. The causal agent also quite often dictates the type of response to be made (eg. an earthquake may necessitate the use of air transport because of the extensive disruption of surface traffic).

5. Disaster agents differ in speed of onset - rapid onset refers to a disaster which causes an immediate move from normality to emergency. An example of this would be the tidal waves that struck Crescent City, California in 1964. Gradual onset refers to a situation in which the agent begins slowly and increases steadily in intensity until a disaster situation is reached. Floods are a good example of this type of agent. Still other disaster agents have a repetitive nature. Often earthquakes will have several shocks of a repetitive nature.

6. They differ in the length of possible forewarning - this aspect is not necessarily related to the speed of onset. It is also quite important because it allows the opportunity for protective action. It appears that the length of forewarning is directly proportional to the amount of organization exhibited by the community afterwards. When the period of forewarning is very short or non-existent, the amount of social and psychological stress is greatest. It has also been suggested that in the past when there is very little forewarning, the

emergence of a communication and authority center is problematic.

7. Disaster agents differ as to their duration - a flood may worsen over a period of time, whereas an explosion would be an instantaneous occurrance.

8. They differ as to scope of impact - In general the more serious disasters are those which are diffused throughout the community with multiple impacts. The localized disaster causes less disruption, and therefore organization of relief efforts is not as great a problem.[13] Dr. Fairley has noted that "If the scope of the impact is small enough, the disaster-ready organizations can deal with it alone, usually helped by the family groups directly involved. But in large-scale disaster, formal organizations can meet only a small fraction of the need for immediate rescue and relief services, and informal mass action must play a large part if loss and suffering are to be minimized."

9. Disaster agents differ as to their distructive potential - damage to property and loss of lives are not always directly related. In general, the more distructive an agent is the more organizationally relevant problems will be. "The degree of damage is inversely proportional to the speed with which restoration of community equilibrium may be accomplished. When the impact is great,

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[13] Dynes, p. 52.

there tends to be a lack of cousensus pertaining to just what action should be taken in the impact area."[14]

John W. Powell has divided disaster impact into eight stages along a time dimension. These conditions are as follows:

	Stage	Function
	Predisaster Conditions	Determine to some degree the effort of and response to impact
	Warning	Precautionary activity
	Threat	Survival action
Emergency	Impact	"Holding on"
	Inventory	Diagnosis of situation and decision on action
	Rescue	Spontaneous local organized extrication and first aid; some preventive measures
	Remedy	Organized and professional relief, medical care, preventive and security measures
	Recovery	Individual rehabilitation and readjustment; community restoration of property

[14] Dynes, p. 54

and organizational preventive measures against recurrence.[15]

In past disasters the main organizational problems have existed in the rescue and remedy stages. Because of the independent nature of relief organizations as they currently operate, the confusion is multiplied and quite often responses are unnecessarily duplicated.

Along with the temporal characteristics of disaster are their special characteristics which can be illustrated as in Figure 4. This pattern provides certain clues to the behavior of populations with different kinds and degrees of involvement in the impact. It should be noted that with the international disaster agency which is being used as the basis for this study, two more concentric rings would encircle the impact area. One at a national and one at an international level.

Concerning the diagram, the impact zone is the area of primary destruction to property, life, and organization. This area is divided into an area of fringe impact. The total impact area comprises that region in which the disaster agent was felt in full force. The fringe area is that area which received only

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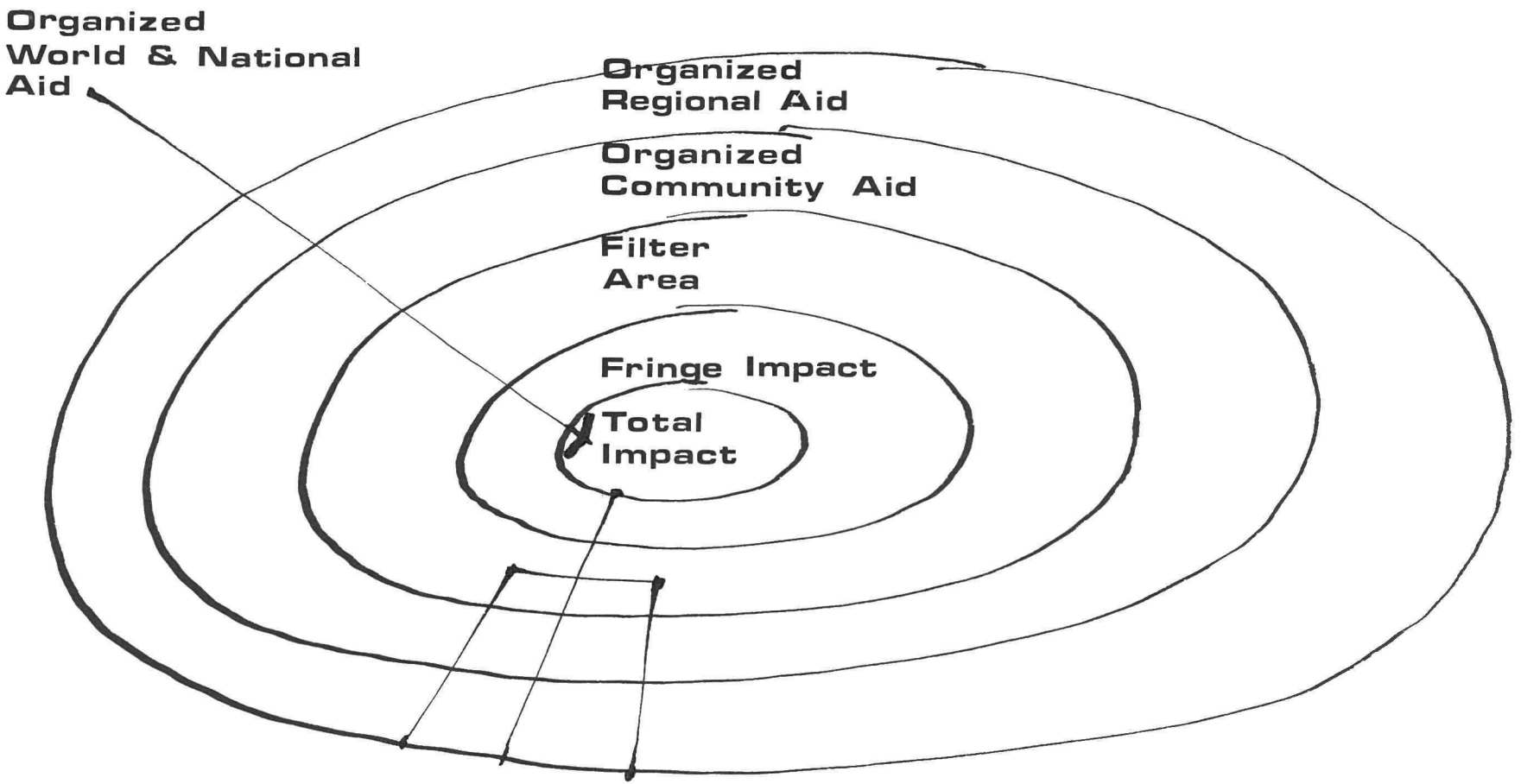
[15] Dynes, p. 55.



spatial characteristics of a disaster

fig. 4

minor damage and few or no serious injuries. The population and area in the total impact zone are the primary concern in the activity following the disaster. The population in this zone is involuntarily involved in the disaster, whereas the population in the fringe zone may or may not be involved. The filter area is that region through which both supplies and information must pass to reach the impact zone. It is at these points that traffic and communications are likely to become jammed. This area, therefore, represents somewhat of a screen to prevent or permit certain information into the impact area.

Note: It must be remembered that the diagram is not a geographical lay-out. The areas being considered will not necessarily form concentric bands around each other. In reality, the total impact area may be spread over a large area with some areas being harder hit than others (eg: earthquake). In such a case, the other organizational levels would exist, but their locations might be intermingled throughout the impact zone (eg: the filter area).

It is the filter area that quite often tries initially to provide those transportation, communication, medical, manpower, etc., needs which have been disrupted by the disaster agent. Quite often this area provides volunteers to perform filter functions into and out of the total impact area.

The areas of organized community, regional-national, and international

aid are only selectively affected by the impact. Only if the community is unable to cope with the situation quickly and effectively and in an organized manner will outside aid enter into the picture.

In developed countries these patterns of response are very easily seen, but in underdeveloped countries the patterns of response may be weighted quite differently. In many instances the community, region, or possibly even the country will not be able to provide adequate aid to the disaster area. In fact, in some cases the disaster may cause such stress on a community that the fringe zone will increase in size because of indirect causes. For example, the water supply may become contaminated as a result of earthquake damage. If there is no rapid solution given the problem, disease typhoid can easily generate and spread through the community and into surrounding areas, multiplying the problems. In such a case, other countries are usually asked to help in the relief program, but often after such a multiplication of problems has already arisen.[16]

Probably the most significant initial task for the organized activity of a community after a disaster is the initial rough estimate of the damage. This is done so that those involved in the organizational activities will have some

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[16] Dynes, p. 58

means for determining when and what resources and services are needed. The possibility that some crucial task may be overlooked while other less important tasks are being performed often inhibits organizational action. For a person or community with little or no disaster experience, this assessment may prove to be quite a problem.

Medical Considerations

Implicit in the word "disaster" is the notion of human injury and suffering. While in some types of disasters medical problems are minimal, in others they are quite important. Studies show that much of the initial work is done by spontaneous rescue groups. Within these groups first aid knowledge is usually minimal. Even in instances where first aid stations have been established, quite often they will be bypassed because of the inferior treatment implied in the words "first aid." This phenomenon occurs more often in those areas which are considered developed. Hospital facilities in developed countries are usually well distributed and supplied with "modern miracle" equipment so it's no surprise that people will try to reach such facilities rather than be subjected to "first aid."[17] While most hospitals contain emergency facilities and staff trained to

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[17] Dynes, p. 59.

cope with emergency situations, the large number of victims in some disasters puts severe stress on the facilities. Hospitals not only have to cope with the additional emergencies but are often called upon to provide special medical teams for special needs and to provide special supplies for aid station in the impact area. The demands of personnel and facilities may create disasters for non-disaster patients who have to be evacuated or temporarily ignored. The demands of much of the day-to-day work of a hospital are of an emergency nature in themselves. Compared to other organizations, the hospital has very little control over its work load or many of its key members and therefore operates constantly on a basis similar to that of a disaster.

In areas where there are inadequate medical facilities, the problems are once again multiplied considerably. In such cases there are two main alternatives for providing prompt and efficient medical care. Expert medical care can either be moved to and operated on the scene, or patients can be stabilized and carried to medical facilities by transportation sources which have been brought into the area.

Because of the powerful destructive capacity of disasters, emergency medical problems of all kinds are encountered. It is therefore difficult to cite specific medical problems which relate directly to or result from specific disaster agents. A few generalities can be made, however. Disaster agents such

as explosions or volcanic eruptions quite often result in large numbers of burn cases. Injuries resulting from tornadoes, hurricanes and similar agents include primarily external lacerations and punctures, internal organ injuries, bone fractures and limb loss due to falling structures and flying debris. Earthquake injuries are primarily similar to those caused by toronadoes. Accompanying these problems, however, may be outbreaks of disease due to destruction of sanitary sewers and water facilities. Shock, infection, and along with psychological and social problems are probable in any disaster. It would be a mistake to rely solely on such generalities. When a disaster does occur a medical unit specifically designed for relief caused by any disaster agent should have the capability to handle any emergency.

Houghton F. Elias, M.D., suggests the following steps in administering to disaster victims:

1. Plan with the Disaster Committee and design a variable hospital flow plan.
2. Plan for admittance tags to be tied to the patients.
3. Plan for manpower to move litters and for plenty of litters.
4. Establish an external traffic control for relatives and outsiders.
5. Provide for a communication center and morgue in adjacent areas.

6. Plan, discuss and rehearse x-ray traffic flow patterm.

7. Establish a "Buddy System" for notification and transportation of surgical teams, prearranged with alternate personnel.

8. Plan for shift arrangements.

9. Plan for care of contusions, abrasions, lacerations, crush injuries, penetration wounds of soft tissues, simple and compound fractures; head, face and neck injuries, 12 per-cent; thorax, 15 per-cent; abdomen, 14 %; extremities, 22%; and lower extremities, 37%. In case of atomic attack there will be radiation effects plus more severe burns.

10. The mission is to save lives, then limbs; save function; appearance can be improved later.

11. Hemorrage must be controlled; airways must be maintained; shock must be controlled.

12. Triage must be established; it requires mature judgment, quick, sound decisions.[18]

The following clinical management suggestions were also given.

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[18] Elias F. Houghton, "Management of Mass Casualties," Emergency Health Services Digest, No. 3 (Summer 1971), p. 58.

Wounds - Best handled by thorough cleansing, using irrigating solution to remove dead tissue and foreign bodies; splinting with loose dressing; gentle packing allows for secondary closure later; draining neck and chest wounds.

Fractures - Reduce, if possible, and apply splints; split cast if pressure developes on fractures that cannot be reduced fully.

Antibiotics - Wide range should be stored for emergencies because 90% of the patients with open wounds and burns will need parenteral administration for 5 days.

Evacuation - Those with fractures of the cervical spine should be transferred in a supine position with a horseshoe type splint made of rolled blanket fastened about the head to prevent motion of the neck. Fractures to other portions of the spine are best transported in prone position; the unconscious and those with jaw fractures should be transported on their side.[19]

Further studies are provided by James Fairley, M.D. The following discussion is a result of his findings and comprises the disaster plan currently being used in Great Britain.

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[19]Houghton, p. 58, 59.

After a disaster has occurred, a major hospital is determined as a "pivotal" hospital and automatically provides the senior medical officer to take charge of all medical and first aid services at the site. All other hospitals are termed "supporting" hospitals. A concise description of the disaster must be provided to each of these hospitals (both primary and secondary).

The arrival of a senior doctor at the disaster site is considered possibly the most important step. It is the responsibility of this physician to:

1. establish a medical services report center
2. co-ordinate the medical and first aid resources
3. formulate the casualty evacuation plan in consultation with the senior ambulance officer.

The site of a major disaster is always one of confusion and congestion. It is essential that clearly recognizable pivotal points be established. The medical services report center is one of these pivotal points. It should be in constant communications contact with all other pivotal points which will vary in number depending upon the extent of the disaster area.

In the early stages following major disasters the extent and type of medical aid needed at the site are difficult to determine. Mobile medical units

are provided if the need arises. These are comprised of specialized teams as follows:

1. medical team
2. surgical team
3. resuscitation team
4. other specialty teams (eg. dental)

These teams are provided by the primary and secondary hospitals. It is important that each facility be well marked and well lighted so that victims can easily locate it during the daytime or the night. Medical personnel should also be clearly marked. An operating theater must be readily available, together with the full supporting services of radiology, pathology, a blood bank, a physiological lab, and other specialties.

Casualty posts are also established near the medical units. These become filters to insure that priority is given to those most in need of help, particularly those requiring life-saving surgery. If any of the casualties are sent to other areas for further treatment, it is essential that they be tagged with a label giving brief details of any treatment which has been given.

It is the responsibility of the senior medical officer to distribute the

flow of emergency cases to the available medical centers.

Throughout the entire operation it is imperative that a communications system be effectively organized to coordinate relief activities. A disaster victim inquiry bureau should also be established as soon as possible.

All of these arrangements are directed toward saving life and reducing pain to a minimum. The dead however must also be considered. Emergency mortuary arrangements, including disposal of the dead must also be provided.[20]

Although this is a limited scope plan for a highly developed country, it nevertheless contains many important elements essential in the development of any type of disaster program.

In the United States most major communities have disaster plans. Most of these plans are relatively small scale and because of political boundaries usually operate in the confines of an individual community or city. At the present time, emphasis is in the area of providing efficient medical mobile stabilization units to disaster victims until they can be delivered to medical facilities that contain sophisticated equipment for diagnosis and treatment. These programs in

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[20] Fairley, p. 552.

the past have proved quite effective in dealing with rather small scale disasters in developed areas, but in situations such as the 1970 earthquake in Peru in which 70,000 were killed and thousands more injured they have little significance. There needs to be a more comprehensive approach for dealing with masses of injured people.

The United States government Public Health Service currently provides disaster relief equipment in the form of a Packaged Disaster Hospital and more recently a Natural Disaster Hospital. These units have been used throughout the United States and even in other countries which have been hit by disaster. Included in each PDH unit are medical supplies sufficient to handle approximately 200 persons in the event of mass casualties. These supplies include: drugs, surgical supplies, cots, electrical generator, water supply system, dental supplies, x-ray equipment, all packaged and stored throughout the country. The initial reason for establishing this PDH system was to provide medical aid in the event of nuclear war. The PDH units have been supplemented by the Natural Disaster Hospital Units (NDH) which contain the same essentials but in smaller quantities. In past disasters the hospital units have proved to be quite effective. In some situations only parts of the unit have been used to supplement the supplies and facilities which the community already had in operation. At

goals

other times, the unit has been used as a complete medical center organized within some structure not damaged by the disaster agent. In cases such as this, problems have existed in notifying people of the aid center's location. Other problems have also arisen from after effects of the disaster. For example, the aid center may become flooded and require movement.

In still other cases such as large scale disasters in underdeveloped countries, many of these PDH units have been airlifted in and assembled as self sufficient medical units. Quite often tents are used to contain the equipment if other shelter is not available. In 1970 several of these units were airlifted into former Biafia and set up to treat casualties. Several basic deficiencies were noted. There was no transformer to convert 110-volt equipment to the local 220 current. There was no blood storage unit. Some of the drugs were contaminated, some of the equipment was outdated.[21] It can be clearly seen that the present system of distribution and operation of these units is by no means efficient.

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[21] Peter Mustell, "Correspondence," New England Journal of Medicine, July 1971, p. 125.

concepts

general

specific areas

Major Goals

1. To establish, within the structure of an International Disaster Center, a system of mobile emergency medical centers which can respond quickly to disasters anywhere in the world and provide organized and efficient medical treatment for victims.

2. To improve present systems of medical assistance to disaster areas.

Note: In the past, physicians taking part in medical relief operations under large scale disaster conditions have taken the inadequate facilities and conditions for granted. Sterilization is considered an impossibility. The attempt is made to save as many people as possible with whatever facilities are available. To improve upon these conditions a medical relief system would have to be established and put into operation almost instantaneously after a disaster has occurred.

3. To fund the project with monies received from various international organizations so that control of the organization will be by an independent body unbiased as to race, creed, color, or national origin.

General Concepts

1. Mobility - (a) through a world wide communications network, medical units located in strategic places throughout the world can easily mobilize to respond to a disaster. (b) the unit should have the capability of being delivered to any site situation and should therefore not be restricted by geographical limitations.

2. Flexibility - after an analysis of the personal damage on the scene, the units should have the capability of providing quality medical service for whatever types of injuries or illnesses are prevalent.

3. Identity - the units should be easily identifiable as emergency medical aid centers--not "first aid."

4. To meet increased casually needs, more than one hospital might be brought to a disaster scene. A group of hospitals could organize in one area, each providing a specific service or the units could be spread over a large area to provide easier access to those needing help.

5. Self-sustaining - the unit should have the capability of becoming a complete self-sustaining unit in the event that utilities are not available.

6. Ease of establishment - the hospital should be easily set up and set in operation.

7. Structural integrity - the unit should be structurally capable of resisting damage caused by long duration disaster conditions (eg. aftershocks following a major earthquake; increased water levels in flooding conditions).

8. Ease of maintenance - the facility should be cleaned and decontaminated easily.

9. Economical equipment should be economical, compact, easily handled, durable; and should be able to withstand transportation impact.

Specific Activities

Admissions - The casualty entrance to the facility must be clearly marked, well illuminated, and as easily accessible as site conditions will allow. This will require locating the facility in such a position that casualties arriving in vehicles, as well as those on foot, can easily enter the treatment center with as little conjestion as possible. A covered area should be provided to protect incoming casualties from the weather as they are being transferred from motor vehicles to the facility.[22] The door opening at the point of entry should be wide enough (about 6 ft) to permit a stretcher with attendants and transfusion apparatus to pass through with ease and dispatch.[23] A supply of stretchers should also be provided near the entrance so that they can easily be distributed to rescue personnel and incoming casualties.

It is essential that some type of police, military, or other security protection be provided to regulate the flow of patients entering for sorting and to prevent unauthorized personnel from entering. Relatives and friends of disaster victims should be denied access to the treatment area and should be

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[22] Guidelines for Design and Function of a Hospital Emergency Department, American College of Surgeons, The Committee on Trauna, Chicago, 1970, p. 11.

[23] Isadore Rosinfield, Hospital Architecture Integrated Components, (New York: Van Nostrand Reinhold, 1971), p. 7.

discouraged from lingering around the facility.

Sorting - A large area should be provided just inside the entrance for the sorting of casualties. Sorting (triage) is the basic procedure in caring for large numbers of persons at one time. It provides a means of placing casualties in treatment priorities, with the objective being to save as many lives with as much human function as possible. Time and vital supplies must not be wasted on hopeless cases. Persons receiving immediate medical care will, therefore, be those for whom a short period of treatment or a relatively simple procedure will significantly improve the prognosis. Severity of injury, per se, is not the determining factor in assigning treatment priority. Patients with injuries, whether major or minor, whose treatment would demand considerable time or supplies, must be placed in a delayed or expectant treatment category and receive only emergency or supportive care until sufficient personnel and facilities are available.[24]

In mass disaster, speed and competence are the most important medical functions. Since the two fundamental components of sorting are diagnosis and

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[24] Treatment of Mass Civilian Casualtes in a National Emergency (U.S. Public Health Service, 1970), Series C-5, p. 4.

prognosis, this function should be assigned to experienced surgeons with the help of nurses and assistants.

The patient should be prepared for examination by removal of sufficient clothing to allow inspection, Unconscious patients should be completely undressed so that injuries covered by clothing will not be ignored. After examination, an assistant should record the treatment category, diagnosis, and any treatment or medication given at the time of sorting on an emergency medical tag attached securely to the body of the injured person. Clothing should accompany the patient unless radioactive or otherwise unusable since clean clothing may be in short supply.

Sorting assistants should be trained to carry out immediate life-saving procedures, such as control of hemorrhage, maintenance of airway, and defibrillation. Except for such emergency procedures, treatment should occur in the ward areas. After examination, patients should be promptly removed to the appropriate treatment area by personnel not involved in the sorting procedures.

The patients are assigned to one of four treatment categories:

1. Ambulatory - Treatment given to patients not needing hospitalization and for which ambulatory care can be given. As some persons complete their

therapy in this category, they may be asked to assist in either medical or housekeeping functions in the hospital. Persons not needed should be promptly discharged with instructions for follow-up care if needed.

2. Immediate Treatment - The principal attention of all persons is given to the care of patients in this category. This will include not only those persons with relatively minor injuries who cannot be classified as ambulatory, but also more severe cases for whom relatively simple or brief treatment procedures might prevent prolonged illness, disability, or death. Examples of types of injuries falling into this category are: easily accessible hemorrhages, easily correctable respiratory defects, incomplete amputations, open fractures of major bones, uncomplicated soft tissue wounds, and burns of 15% to 40% of the body. A patient receiving an immediate treatment classification should be removed immediately to an area where that particular type of treatment is being administered.

3. Delayed - Treatment which might be delayed without immediate jeopardy of life, or conditions demanding time, equipment, or personnel in quantities not feasible under the disaster conditions. Patients will include those with minor injuries who are unable to care for themselves outside the facilities, those

patients who have major injuries but whose condition will not be significantly worsened by a delay, and those patients severely injured requiring time consuming intensive care. As personnel and facilities become available, these casualties will be reassigned an immediate treatment classification.

4. Expectant Treatment - Those patients who are severly injured or whose prognosis is poor are put into this category. The conditions make an eventual recovery doubtful. As the patient load decreased it may be possible to promote surviving patients into an immediate treatment category.[25]

The principle factor determining the category into which a patient is placed is usually not the severity of the injury but the length of time needed for treatment. Sorting is a continuous process to be repeated in all areas of the facility at different times so that patients are constantly being reclassified.

Whenever a person dies, the body should be removed immediately to a morgue area where it can be prepared for immediate disposal.

During the entire sorting procedure, sorting officers should be informed

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[25] Treatment of Mass Civil Cas., pp. 5-9.

as to the number of patients in each treatment area. This will prevent flooding of any one particular area.

The sorting area should be provided with resuscitation, ECC, defibrillation, respiratory support equipment, and emergency drugs.

Places should be provided where sterile supplies can be had on clean carts and where used supplies can be collected for discarding or processing. Electricity, oxygen, compressed air, and suction should be available in the area.

Records - A information and records area should be located adjacent to the sorting area. The patients' records are started at this point if time permits. If not, they are started in the first section to which the patient is moved and brought back to the records area. Files on each patient are kept current, noting the classification of each patient.

Obtaining information from casualties should be done as quickly and efficiently as possible during the treatment or diagnosis.

Patients' Personal Effects - Personal effects should be collected when necessary, tagged and kept with the patient. If possible, some locker storage should be provided also.

Decontamination - In the case of patient exposure to radiation, a showering area should be provided outside the main facility. Decontamination consists of removing radioactive clothing, showering or washing exposed skin, and, if necessary, cutting the hair. After decontamination, the patient can enter the main facility for treatment. Periodic radiation monitoring should be done to keep radiation levels down.

Wards - Ward areas are set up at the direction of the chief of staff in consultation with the director of nursing, according to the numbers and types of injuries. He may designate such separate ward areas as surgical, medical, shock, burn, fracture, psychiatric, communicable disease, or holding, as conditions require. There may also be separate wards for men, women, and children. The facility should have the flexibility to be arranged in a number of ways to best meet the needs of the injured.

If, for example, the hospital receives a large number of patients who are seriously injured and in shock, a shock ward can be established for the control of hemorrhage and shock. Equipment for intravenous therapy, suction, and blood pressure instruments are needed in this case.

An observation or holding ward may also be established for patients with

a poor prognosis to receive palliative treatment.

The wards should contain cots, tables, and some type of stretcher holding facility. Each area should be staffed by a team of physicians, nurses, medical aides and assistants.[26]

The following treatment areas should be considered:

1. Ambulatory Treatment - An ambulatory treatment area should be provided for the treatment of minor injuries. This area should be located well apart from other initial treatment areas to avoid confusion. Nurses and medical aides will man this area.

It is essential that patients be kept at a constant flow both into and out of this area. A means of exit from the emergency hospital should be provided for this area. However, this should be for exit only. A security person should be located at this exist to instruct casualties to the main entrance.

This area should be provided with water, clean and soiled goods areas, first aid medical supplies, and an ample number of cots and chairs for use by those being treated.

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[26] Establishing the Packaged Disaster Hospital (U.S. Public Health Service, Div. of Health Mobilization, 1964), F-1, p. 18.

2. Shock - Patients in shock will either be placed in the immediate or delayed treatment categories. Those placed in the immediate treatment category will receive active treatment for both shock and any accompanying injuries. Those placed in the delayed treatment category will also be treated for shock, but further treatment will not be possible until the patient is put into an immediate treatment category.

Personnel with experience in intravenous therapy should be provided in this area along with cots, blankets, intravenous solutions and sets, cross matching units, and infusion sets. Storage should be provided for all the above listed items.

3. Burns - Burns are one of the most common injuries encountered in most mass disaster situations. They may be of first, second, or third degree, determined by the depth of tissue destruction. Treatment categories assigned to burn patients depend upon both the location and extent of the burned area.

All first degree burns, as well as second and third degree burns, of less than 15% of body area should be treated in the ambulatory treatment area. Patients with second and third degree burns of 15% to 40% of the body area will be placed in the immediate treatment category. Patients with second and third

degree burns of over 40% of the body must be placed in the delayed treatment category, since few of them will survive regardless of treatment.

Water should be provided in the space, along with storage for various supplies and intravenous therapy sets.

4. Fractures - Most open fractures not associated with more serious injuries should be placed in the immediate treatment category. Some closed fractures can be treated as ambulatory cases, however.

Fractures or suspected fractures which have not been splinted before arrival to the facility should be splinted at the time of sorting. Coaptation splints using padded boards, should be used whenever possible, although any rigid material will suffice.

Many closed fractures and dislocations with clinical deformity can be reduced easily. Because of the number of incoming casualties with fractures, anesthesia may not be feasible for every case. The physician on duty must determine how best to handle the situation. For some, it may be possible to obtain relaxation and reduction with narcotics and barbituates alone or with infiltration of the fracture site with local anesthesia. If conditions permit general or regional anesthesia, many closed reductions can be done more satisfactorily

using these methods. Children, particularly, should be treated in this manner.

In areas where diagnosis of fractures is difficult or in critical area of the body x-rays should be taken to more clearly expose the problem. Certain fractures will also require placing the patient in skeletal traction, although this type of therapy should be avoided whenever possible, because it adds an additional load to possibly already overburdened personnel.

Immediate and ambulatory treatment areas should contain storage for splints, dressings, and some drug storage. Fracture tables should be provided along with cots in immediate treatment areas. A water supply should be present along with space for anesthetic apparatus. Crutches will also be provided in both immediate and ambulatory treatment areas. Casting areas should be located so that airborne plaster dust will not carry contamination into the surgical areas.

A work counter should be provided in this area, along with ceiling hooks and storage cabinets.

Obstetrics - Gynecology - Most gynecology procedures are elective and except for a few emergency cases emergency disaster could be delayed until after conditions have subsided. Obstetrical admissions would of necessity be limited to

complications of labor such as hemorrhage, abnormal presentation and cephalo-pelvic disproportion. All women in these or other complications of pregnancy would be placed in the immediate treatment category. No patients in normal labor can be admitted, and deliveries will therefore have to be carried out in homes or other shelters. However, if the extent of disaster is such that more than one Mobile Emergency Medical Facility is in operation, provisions can be made if needed for using one facility as an infant delivery area. Therefore, supplies and storage should be provided for this procedure, along with hot and cold water and cots.

Privacy of treatment is one of the major reasons for establishing an OB-gyn treatment space. However, individual privacy should not take precedence over the overall relief effort.

Psychiatric - All patients entering the facility for psychiatric reasons should be reviewed within a few hours by a staff member and a decision made as to disposition (discharge, utilize services within the facility, or confine).

All psychiatric problems must be treated expediently, since the psychiatric staff may be needed in more urgent medical and possibly surgical capacities. The most probable reactions to a disaster would probably be: (1) acute anxiety

attacks, (2) grief reaction, and (3) panic reactions, all of which can be treated with drugs. As many as possible of these patients should be given specific duties, either within the hospital or doing other relief associated activities in the field. This would distract the patient from his own individual plight and allow him to be of aid to others.

Disease - Most of these problems will arise in weeks rather than days after a disaster. Efforts for control will be mainly in the hands of environmental sanitation engineers.

Treatment for those stricken by disease will be mainly by the administration of drugs. Space, if needed, should be provided for individuals requiring isolation from the remainder of the facility. Bedding should be provided for all patients confined within the facility.

General Medical Problems - Patients coming to the facility with emergency medical problems other than traumatic injuries should be routed through the sorting area and assigned to the appropriate treatment category in the same manner as casualty victims. Only urgent conditions will be treated, and wherever possible this will be done on an ambulatory basis.[27]

[27] Treat. of Mass. Civil. Cas., pp. 10-21, 53-61, 74-84.

Dental - Treatment in this area as in other sections should be restricted to only emergency work. One dental chair with dental light should be provided, as well as storage for equipment. Water and vacuum are required.

Surgery - Four operating areas should be provided within the facility with two recovery beds provided for each.[28] Consideration should be given to provision of the following operating areas:

1. General (all cases except orthopedica and gynecology)
2. Orthopedic (fractures, dislocations, etc.)
3. Gynecology (spontaneous abortions, etc.)

In most disasters the general surgery area will receive the majority of cases. The extent and nature of injuries should be evaluated before establishing specialized areas which are not needed. Equipment for each of these areas should include operating tables, surgical lamps, instrument stands, and basic surgical instruments. Sterilization of all instruments should be accomplished in the central supply section.

The surgical wound and the area immediately surrounding it are known as the "sterile field," and every effort is made by the surgical team to prevent

[28] Guide for Des. and Funct. of a Hosp. Emer. Rm., p. 13.

the area from being contaminated. Airborne dust particles are unsterile objects that increase with the amount of traffic that passes into and out of, or even near, the operating area. Therefore, it is important to keep surgical areas somewhat isolated from traffic flows. To further eliminate the possibility of infection in major surgical areas, patients should be provided with gowns to be worn into the area. The surgical area should maintain, if possible, a positive pressure to help prevent contamination and should be situated so as to make use of even shadowless daylight to improve lighting conditions in the area.

Surgical areas should be provided with oxygen, suction, water, AC DC power, and compressed air.

A scrub-up area should also be provided near the surgery area. This area is used by the surgical team for scrubbing before each operations. In addition, it may be used for putting on caps, and masks.

To help expedite the flow of patients into the operating areas, an induction may be established for anesthetizing patients requiring general anesthesia. Because explosive gases are used in general anesthesia, the surgical and induction areas should be equipped with conductive flooring and

explosion proof switches. Three anesthesia units of the closed-circuit, gas-oxygen-ether type will be provided, along with cones and masks for the administration of ether by the open-drop method without the use of anesthesia apparatus.

Along with these major treatment provisions, a number of support facilities should also be provided.

X-Ray - The X-Ray section should be convenient to operating rooms and laboratory. It should contain a minimum of 300 square feet and should be located in an area protected from radiation leakage. Sufficient table space should be available for the processing machine and clerical work. Arrangement should be made so that only the technician is in the X-Ray room.

Provisions should be made for protective storage of unexposed film, as well as filing of completed pictures when returned from other treatment areas.

For 24 hour operation, the X-Ray section will require 3 X-Ray technicians, two clerks and two helpers. When available, a radiologist should have overall responsibility for X-Ray services.[29]

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[29] X-Ray Section of the Packaged Disaster Hospital (U.S. Public Health Service, Dir. of Health Moblization, 1966), F 2, pp. 1-5.

Laboratory - The laboratory will provide a diagnostic function with the following subdivisions being included:

1. Pathology - concerned with the analysis of diseased tissue or fluids and other elements within the body. It is usually divided into micropathology and gross.

2. Histology - concerned with structure composition and function of tissues and also the preparation of tissue analysis.

3. Chemistry - concerned with the chemical analysis of body tissue and fluids. Also, urology is included in this section sometimes.

4. Bacteriology - concerned with bacteria and pathogens found in the body or environment.

5. Hematology - concerned with the study of blood specimens.

Also included in or connected with the clinical lab will be a specimen collection station where patients can have specimens of blood drawn for various purposes or a urine sample taken. The collection station should be equipped with a counter, a sink, a bunsen burner, a supply cabinet, and a toilet.

Patients should not be allowed to circulate through the lab.

An area should also be provided for blood transfusions. The blood drawing area should be as quiet as possible and divided into cubicles with 30" high cots. After processing, the blood is stored in a blood bank adjacent to the acquisition area. The blood should be kept in special refrigerators until needed.

Utilities required in the lab will include wastelines (noncorrosive), hot and cold water, steam, gas, oxygen, electricity (AC and DC), compressed air, and vacuum.

Other special considerations: desks or counters are generally of two heights - 31" for sitting and 37" for standing. Chemistry is generally done in a sitting position. For this reason adjustable desks may be required.[30]

Pharmacy - Provision should be made for secure storage of pharmacentical supplies in each therapeutic category: anesthetics, analgesics, sedatives, antiinfectants, antiseptics, stimulants, antispasmodics, antihistamines, opthalmic medications and large intravenous solutions including resuscitative fluids.[31]

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[30] Rosenfield, pp. 17-22.

[31] Est. the Pack. Dis. Hos., p. 21.

Locked safety cabinets should be provided for those which are volatile. A qualified person should be in charge of the pharmacy, although nurses or aides can assist in the distribution.

This area should be regarded as a supply service and therefore, located in the ancillary division. There should be an area provided for compounding or manufacturing as well as distribution.

Central Sterile Supply - Efficient operation of this section is important because it provides essential support to all treatment areas. The following sections will be serviced by this facility: operating rooms, wards, clinical laboratory, and pharmacy. Such materials as dressings, needles and syringes, rubber gloves, catheters, tubing, glassware, instruments, treatment trays and sets, utensils, and sterile linens will be stored, processed, and issued from central sterile supply.

This area should be divided into two subsections: preparation and sterilization.

The preparation area should be provided with a sink and some provision for linen washing. Items to be sterilized are received, sorted, cleaned, assembled, inspected, wrapped, and labeled for sterilization here. On request

from surgery, packs, trays, and sets are also made up and labeled in this subsection.

The sterilization subsection sterilizes, stores, and issues the assembled packs to the areas of the facility requesting them. Pressure and boiled H20 sterilizers will be provided in the area.

The preparation section will also be a soiled holding, while the sterilization section will become a sterile holding.

Because open flame burners are used in the section, operating and induction areas should be located at least 150 feet away.

The facility should be located near general stores because all clean linens will be stored there, and Central Sterile quite often will requisition linens to be sterilized and issued to operating areas.

The preparation subsection needs storage space for cleaned supplies and instruments. The sterilization subsection needs only table space for sterile storage. The physician in charge of assigning priorities to surgical patients will provide the Central Sterile supply chief with surgery schedules as far in advance as the situation permits. In turn, Central Sterile will prepare the equipment.

Good ventilation is essential in Central Sterile Supply with open flame burners being used. The same degree of cleanliness that is maintained in the operating rooms should be the standard for Central Supply, with diligently supervised cleaning.[32]

General Supply - All but major equipment will be handled by the General Supplies section and dispensed in small quantities as needed by individual sections. Part of these supplies must be sterilized before they can be used; others need not be sterilized. Because of the quantity and variety of equipment handled, this section must be well organized.

Morgue - In the event of death, bodies should be taken as quickly as possible to the morgue area where they can be removed to some other designated area. It is important that contact be provided records area in order that a death record may be established. In order to prevent odor and unsanitary conditions, the bodies should not be allowed to accumulate for any long period of time. If possible, some automotive vehicle should be used to evacuate bodies. There

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[32]Central Sterile Supply section of the Packaged Disaster Hospital, (U.S. Public Health Service, Dept. of Health Mobilization, 1966), F-3, pp. 4-14.

should also be provisions made for storing bodies until they can be transported as well as a special security area for partial postmortens because of deaths from unknown causes.

Administrative Services - Administration of the facility involves hospital organization and acquiring functional help from the stricken community to construct and operate the hospital. Coordination is the responsibility a physician designated as chief of staff and an administrator designated as hospital administrator, the chief of staff having priority in unresolvable situations.

Administrative areas should be provided for both officials as well as for the director of nursing and the communication and messenger staff.

The main functions of the chief of staff are:

1. Determine and establish the nature of treatment areas in the hospital

2. Supervise the assignment of personnel to treatment and technical services, and providing for 24 hour staffing. If the staff is insufficient, request additional personnel.

3. Supervise treatment service operations

4. Keep continuously appraised of availability and need in personnel

and supplies for treatment services and inform hospital administrator

5. If necessary, reduce surgical lag by improvising additional operating facilities and requesting and assigning additional personnel

The main functions of the hospital administrator are:

1. Establish best communications capability possible: telephone, two way radio and/or messenger
2. Establish contact with appropriate organizations and request support services
3. Direct construction of the building
4. Direct equipment movement and activating
5. Obtain needed supplies
6. Maintain pool of untrained personnel for use in the hospital
7. Arrange for security precautions
8. Supervise administrative services
9. Continuously appraise the needs of the facility
10. Maintain contact with the international agency as well as with local branch agencies.

Communications - This is one of the key factors in an effective medical relief program. It is imperative that medical personnel be informed at all times on the relief conditions and activities after a disaster. It is also imperative that the communications center be informed as to the adequacies and inadequacies of the medical units so that incoming victims can be directed to the area where they can receive the best help.

Director of Nursing - The Director of Nursing is responsible to the chief of staff for all nursing personnel (including medical aides) and for organization and supervision of nursing services throughout the hospital. Other duties include:

1. Assist chief of staff in organizing treatment areas
2. Assist in supervising setting up hospital
3. Assign nursing personnel to specific areas
4. Supervise nursing services
5. Anticipate requirements for additional personnel or supplies and report to chief of staff and hospital administrator.[33]

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[33] Est. the Pack. Dis. Hosp., pp. 24-26.

Medical Services/Records - This area is in charge of obtaining vital information from incoming casualties and labelling those individuals in some manner (eg: body tags). The condition of the victim should be noted and kept as current as possible. Besides the initial clinical records, additional records will be maintained in the radiology, laboratory areas, and patient disposition in ward areas to be transferred later to the clinical records area. Friends and relatives can obtain information on the location and condition of a particular patient at any time. However, information center should be established well apart from the receiving and treatment area.

Toilets and Washrooms - These should be provided to meet the needs of 400 patients and personnel. Provisions should be established for disposal of waste materials acrued in the hospital. The disposal should occur at a site away from the medical facility.

Casualty Listings - Plans should be made to inform relatives and friends of casualties in some facility outside the hospital building. Casualty lists and other information should be posted as soon as they become available.

Food Service - This service to the hospital will be provided by associated

groups such as the International Red Cross, as well as local groups. No preparation of food will occur within the medical facility.

Staff Lockers - Lockers, a relaxation area, and facilities should be provided for all staff members.

Conference - A conference area subdivided into smaller units will be provided for special conferences conerning the staff and for patient interviews. If needed, a psychological post can be established in the area.

Maintenance and Housekeeping - Space should be provided for maintenance and housekeeping personnel and equipment within the facility. This should be headed by a member of the staff working with voluntary help. The crew of 40 or 50 will be in charge of setting up and maintaining the hospital in an efficient manner.

The maintenance chief should provide the following services:

1. Recruit help for setting up the hospital

2. See that gasoline and fuel oils or other fuel sources are available for operation of generators.

3. Plan mechanical arrangements for an alternate water supply

4. Prepare plans for emergency heating[34]

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[34] *Est. the Pack. Dis. Hosp.*, pp. 10, 11.

casualty flow

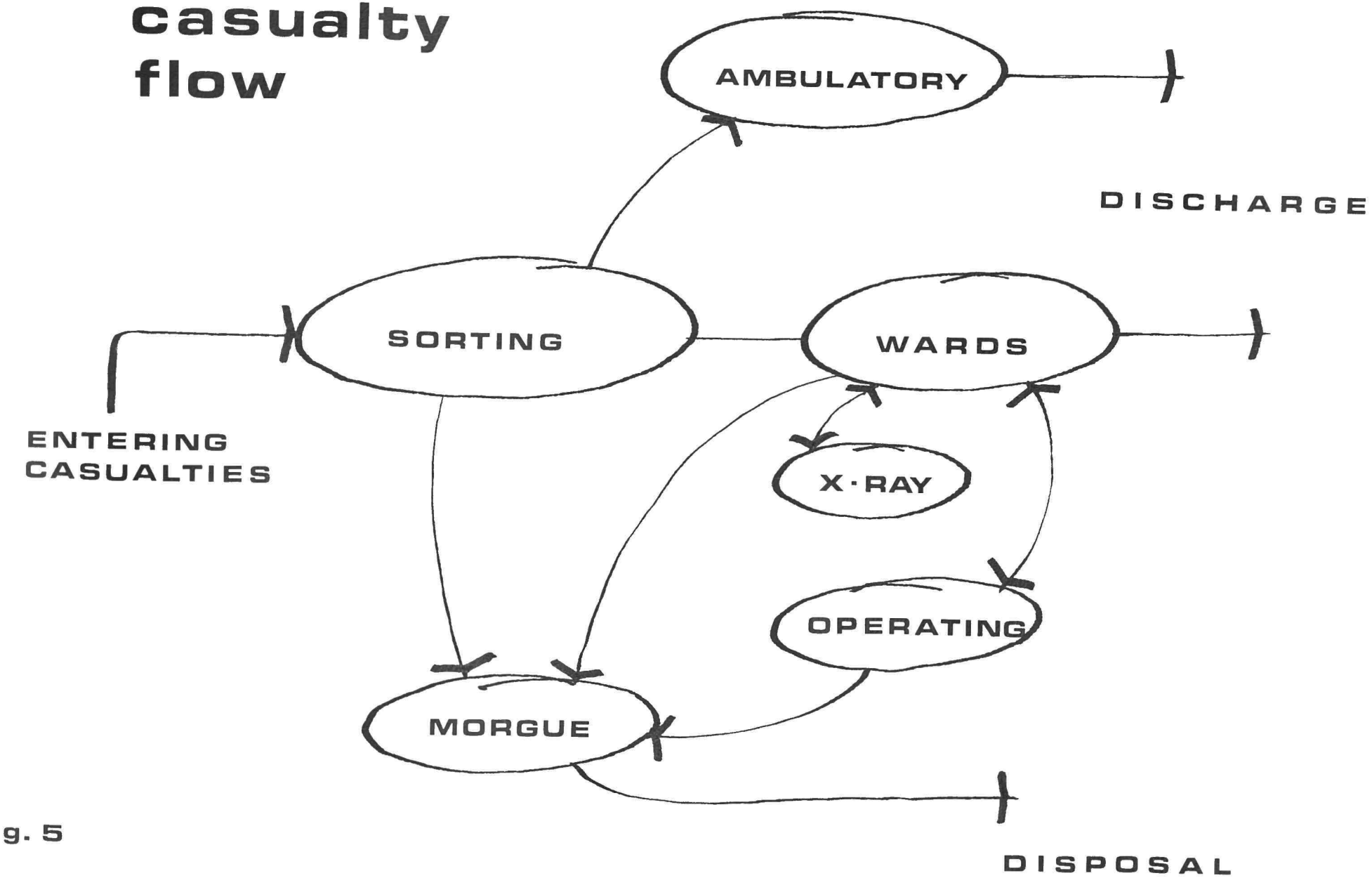


fig. 5

spatial relationships

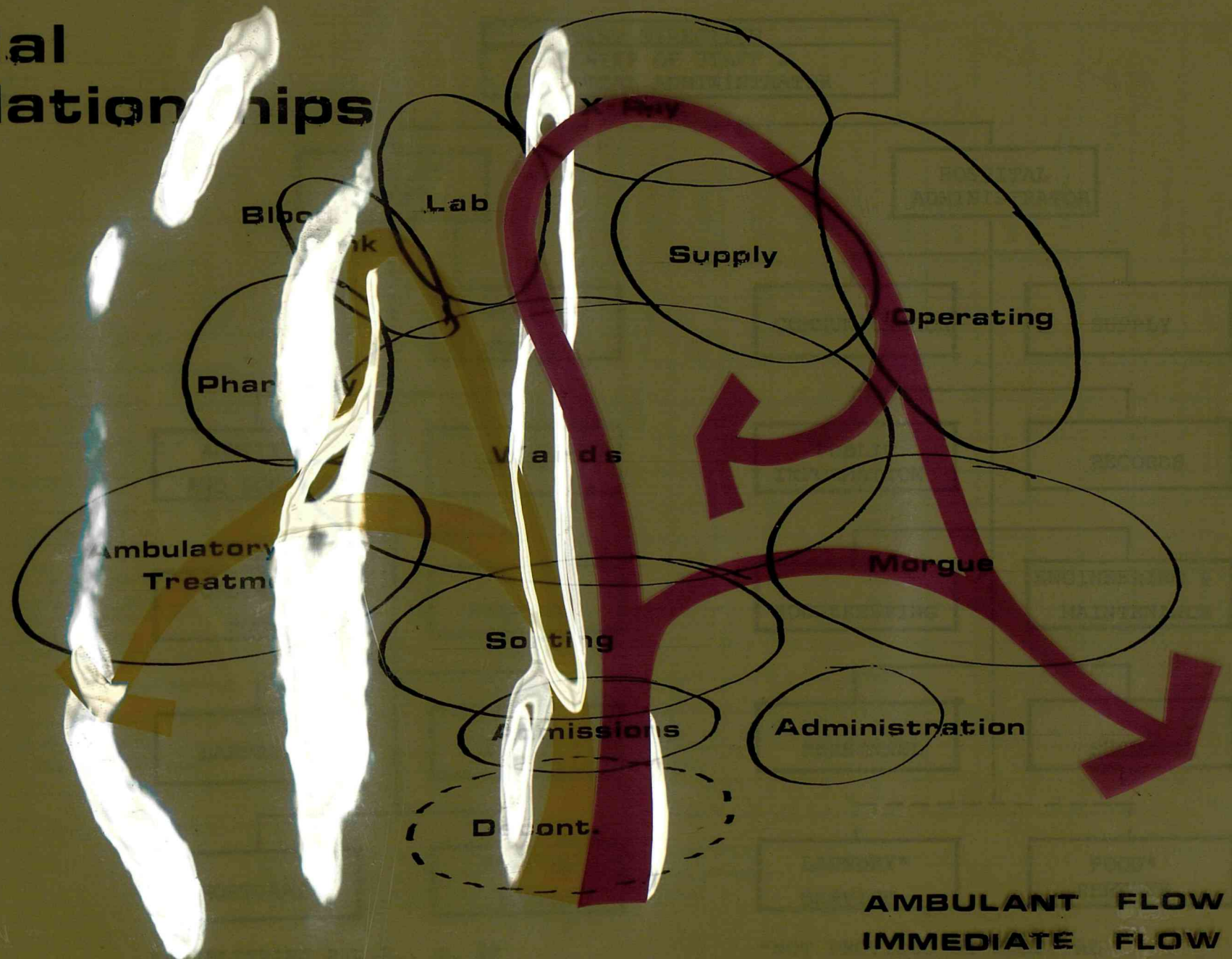


fig. 6

spatial relationships

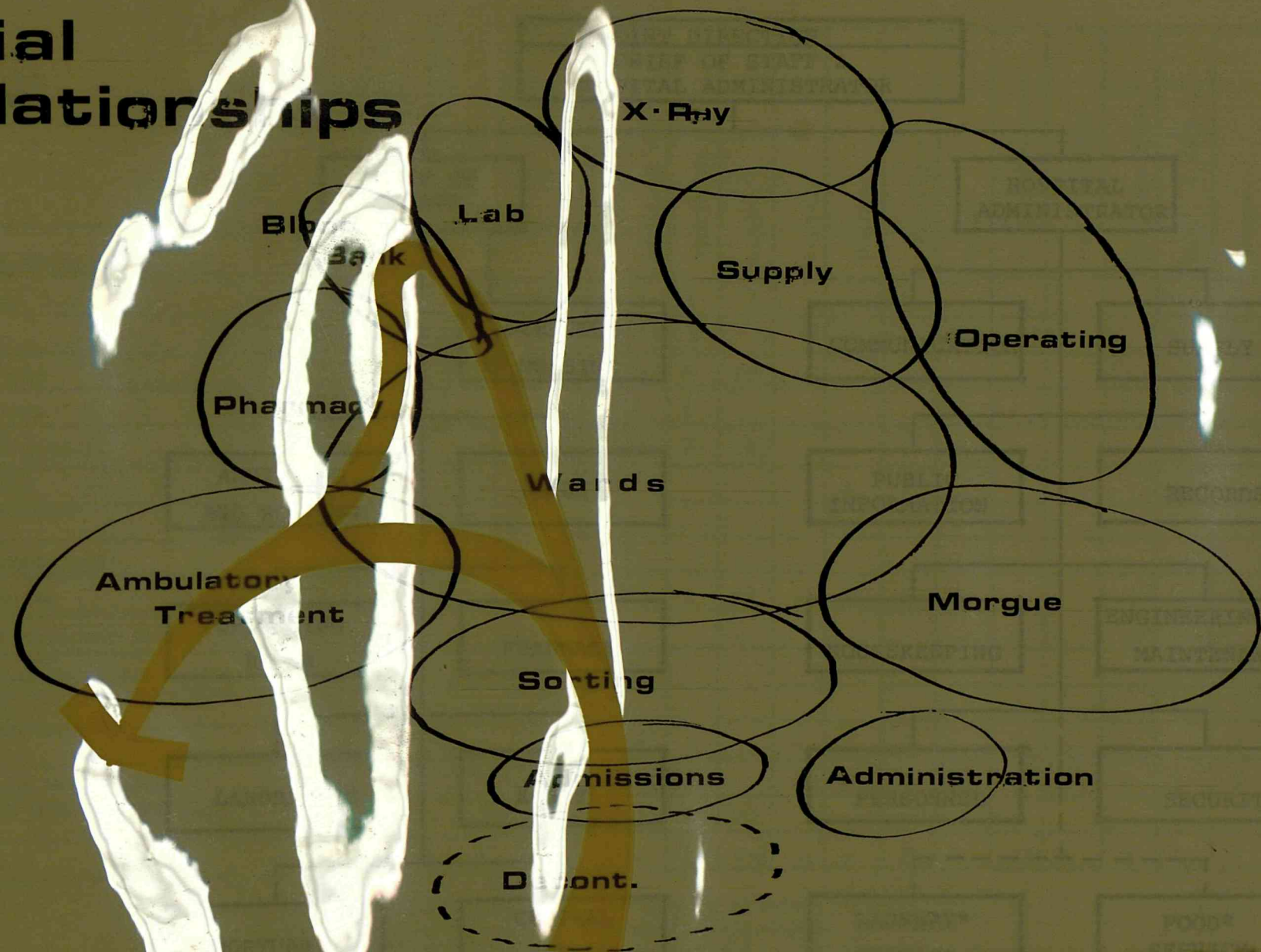


fig. 6

AMBULANT FLOW

spatial relationships

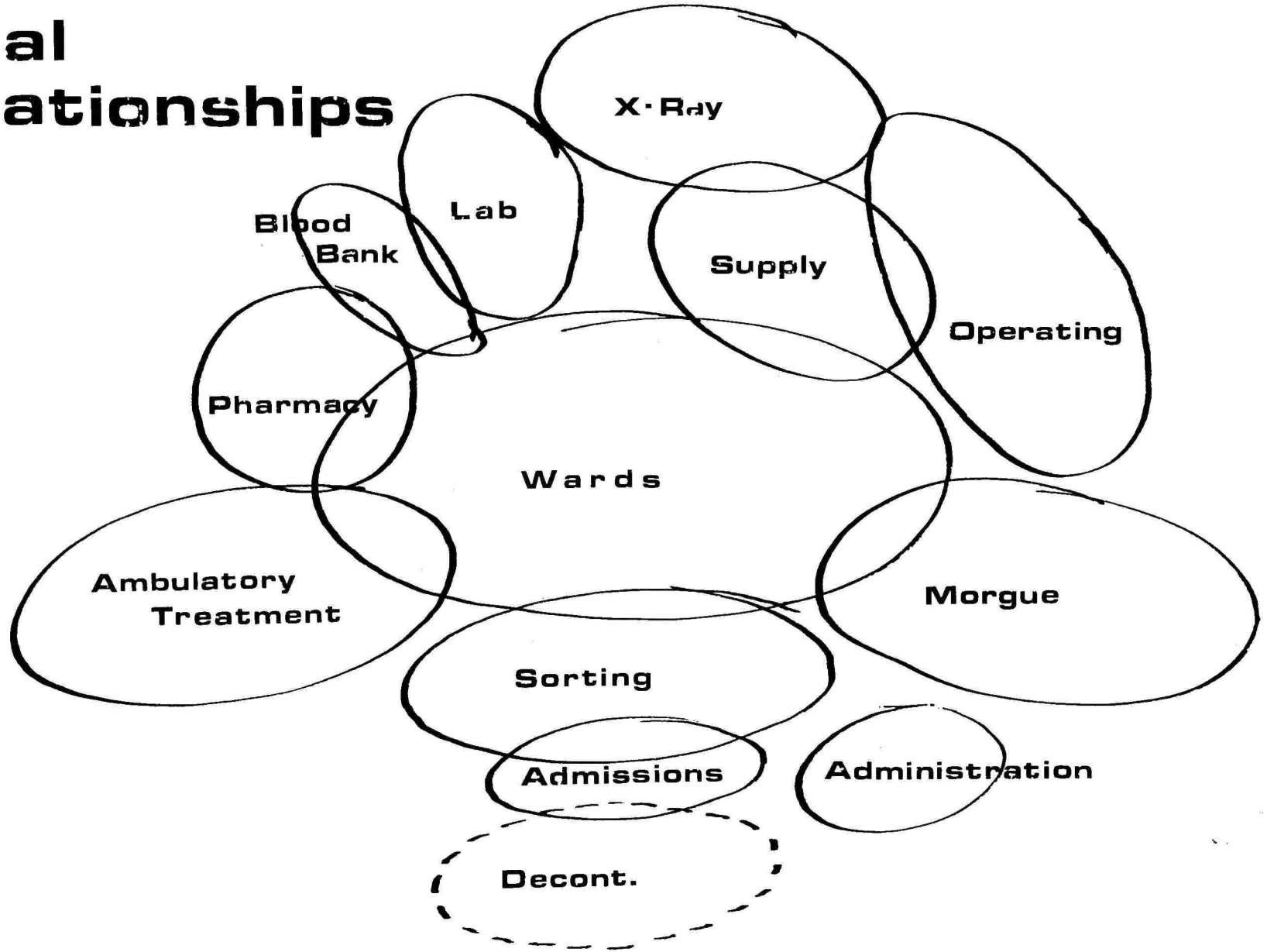
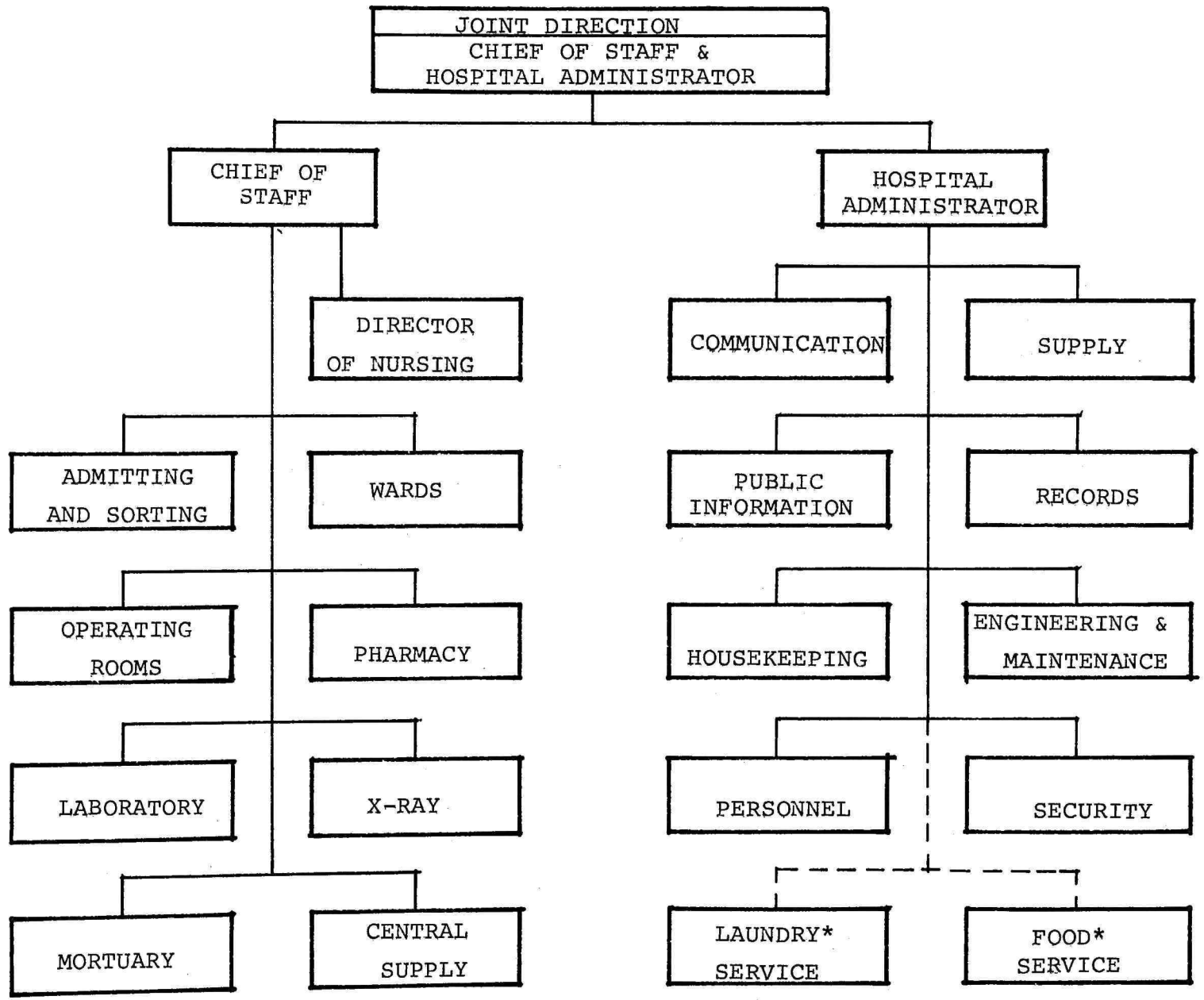


fig. 6

Organization Diagram



ESTABLISHING P.D.H., p. 24

*NOT PROVIDED BY HOSPITAL

Personnel Requirements

PERSONNEL CATEGORY	Admit. & Sort	Operating	Wards	Supply	Pharmacy	Laboratory	X-Ray	Administration	Med. Records	Communication	Engr. & Maint.	Morgue	Total
Physicians	2	6	2										10
Dentists		3											3
Prof. Nurses	2	8	20	4									34
Anesthetists		6											6
Nurses, Practical	2	8	8										18
Pharmacists					2								2
Lab Technicians						2							2
X-Ray Technicians							2						2
Medical Aides	12	6	88	14	2	2	2					2	128
Administrators and Assistants								4					4
Maintenance Engineers											2		2
Chaplains								3					3
Clerks	2			4		2		2	4	4		2	20
Helpers and Messengers	2			16	4	2	2	2	2	4	2	2	38
Custodians and Housekeepers	2	2	20										24
Totals	24	39	138*	38	8	8	6	11	6	8	4	6	296

Notes: Food and laundry service provided by others.
Circumstances may alter personnel assignments.
* Several psychologists may prove helpful in the ward areas.

Emergency Utilities

Utilities Provision for a Self-Sustaining Facility - For emergency electrical source in case power has been lost in the disaster area a generator should be provided, along with an AC to DC transformer.

An emergency water source should be provided with a 1500 gallon capacity, as well as a water pumping unit supplying 10 gpm at 100' head.[35]

A suction and pressure apparatus should be provided for use in treatment areas.

Emergency sewage disposal should also be facilitated.

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[35] Series 10000 Mod "A" Component Listing and Storage, (U.S. Public Health Service, Dir of Emer Health Ser.), F-19, pp. 43, 45.

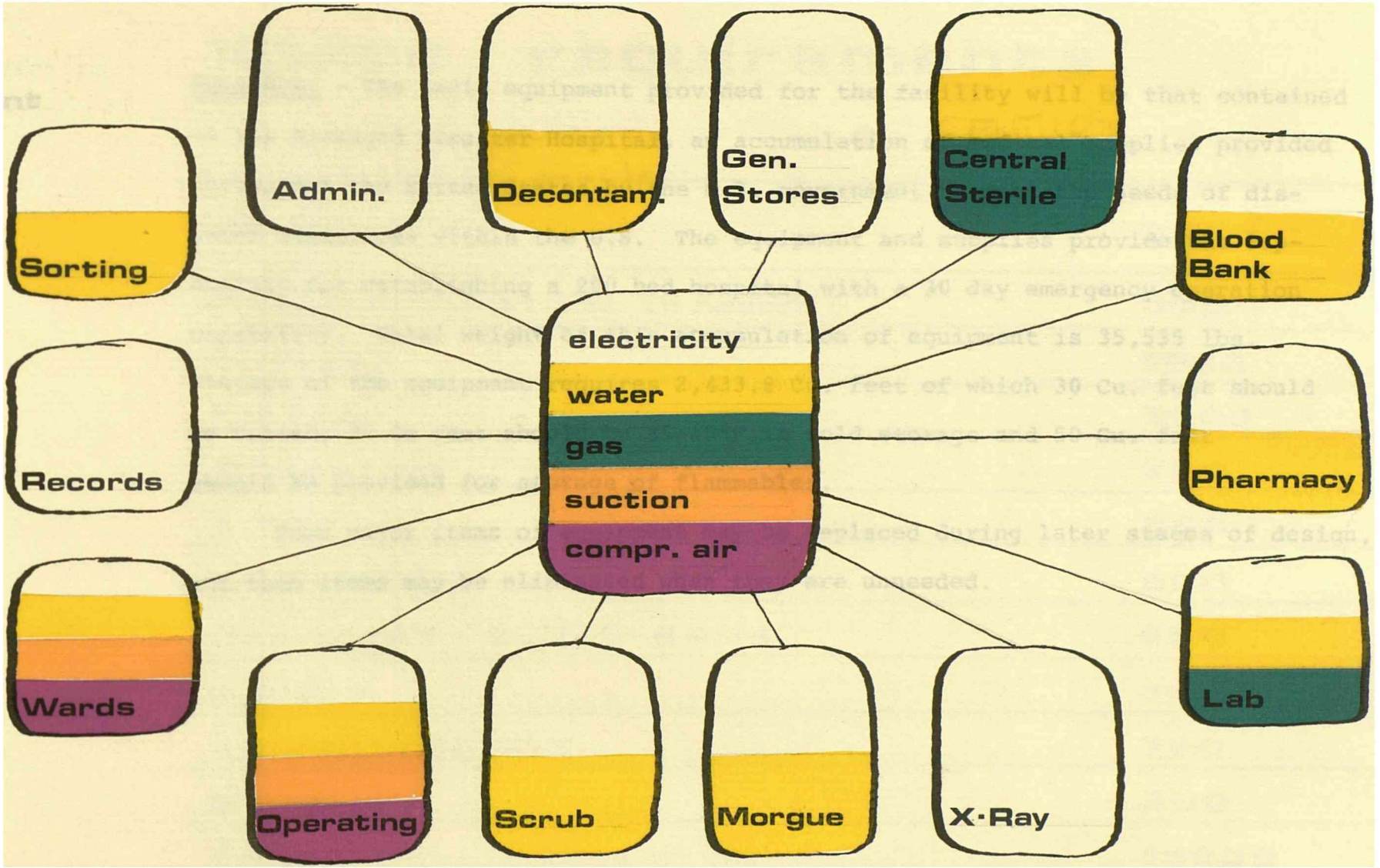

fig. 7

distribution of utilities

Equipment

Equipment - The basic equipment provided for the facility will be that contained in the Packaged Disaster Hospital, an accumulation of medical supplies provided throughout the United States by the U.S. government to meet the needs of disaster situations within the U.S. The equipment and supplies provide the capability for establishing a 200 bed hospital with a 30 day emergency operation capability. Total weight of this accumulation of equipment is 35,535 lbs. Storage of the equipment requires 2,433.8 Cu. feet of which 30 Cu. feet should be heated; 24 Cu feet should be 35-46°F in cold storage and 50 Cu. feet should be provided for storage of flammables.

Some major items of equipment may be replaced during later stages of design, and then items may be eliminated when they are unneeded.

space requirements

area	sq.ft.
DECONTAMINATION (if needed)	300
SORTING	1200
WARDS	9300
OPERATING	750
X·RAY	300
LABORATORY	200
PHARMACY / BLOOD BANK	650
SUPPLY	1450
ADMINISTRATION	750
MORGUE	300
TOTAL	15200

fig. 8

Prevention of Infection

Hospital acquired infection prevention is generally dealt with under these headings: (1) antibiotics - a means of preventing infection and dealing with it after a patient has acquired it, (2) germicides - a means of preventing growth of pathogenic microorganisms in the hospital or destroying them if they are present, (3) administration - organizing work processes to prevent transmitting infection, and (4) architecture - devising the hospital building so that it will minimize the entry, growth, and trasmission of infection in the hospital.

A number of methods have been used in the past to help combat the problem of infection, and in modern hospitals procedures have become quite complex involving masses of sophisticated equipment for conditioning and treating the air. Disaster conditions, however, may tend to prevent the use of such bulky, expensive equipment.

However, before technology produced these systems, which have proved quite effective, a number of other techniques were employed in an effort to prevent the spread of infection.

One of these ideas was to segregate patients in separate pavilions connected by open corridors intended as an aseptic break to prevent carrying

contagion from one area to another.

Another idea was to place beds a certain distance apart. The Hill-Burton Act used extensively in hospital building at the present contains regulations in this regard.

Natural and ultraviolet light have also been employed in an attempt to prevent infection. However, it isn't certain just what values these measures hold.

Germicides are used in cleaning agents to halt infection. This appears to be one of the most efficient methods and is also the easiest to administer.

In general, it can be said that to prevent contagious infection, the hospital and all equipment and personnel should be kept as clean as possible.

In designing the facility this should be kept in mind.[36]

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[36] Rosenfield, pp. 149-154.

Inteiors: Light & Color

Adequate lighting should be provided in all work areas, whether it is derived from natural or artificial sources. If electrical power has been interrupted in the area and the facility is depending upon its own generator for power, frugality should be exercized with electricity. During daylight hours an effort should be made to use natural lighting as extensively as possible.

Color is also important consideration in the facility. White should be considered for sanitation purposes. However, looking at red (blood and human tissue) against a backdrop of white is fatiguing to the eyes; whereas green, complementary to red, presents a restful background.

A variety of other bright colors should be used in the facility for visual relief. Graphics should also be brightly colored so as to help the facility operate more efficiently.[37]

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[37] Rosenfield, pp. 157-162.

Site Considerations

After entering a disaster zone the initial reconaissance team should report on the nature of physical destruction and human suffering in the area. The team should also select a site or sites where the hospitals will locate. They should be located as nearly as possible to major casualty areas. However, if utilities cannot be provided from local sources in these areas, the facility may be located a little farther from the area in order to take advantage of the facilities. If land clearing is required to remove debris scattered by the disaster agent, it should be done by the technical unit as soon as possible before the arrival of the mobile unit.

Ideally, the facility should be located on a flat, or relatively flat, site. It should not be located directly on a major traffic route, although it should be easily seen and accessable from these routes. Access to and from the facility should be provided from several different points in order that emergency vehicles can easily deposit casualties, and so that service vehicles (food; body disposal, etc.) can easily move in and out of the area. Ideally, these traffic routes should be paved, although it may not always be possible to find a location with paved roads. Along with access ways, a limited amount of parking space for those assisting in rescue and medical procedures should

be provided. However, persons not involved with the hospital, directly, should be discouraged from entering the area.

The facility should not be located in low lying areas which may be subject to flooding . It should also be located in such a way that drainage will occur away from the facility.

Ideally the facility should be located in an area that has access to locally provided utilities (water, sewage, electricity, gas). The facility, however, will have the ability to sustain itself if these services are not available.

Any physical structuring should be oriented in such a way as to best utilize natural energy sources (eg: solar energy for heating ; natural lighting, breezes for ventilation).

Codes & Regulations

Because of the special nature of the facility being considered there are currently no codes or regulations which must be complied with in either building or supplying the facility. However, when applicable, regulations set out in the Hill-Burton Act will be followed as a standard. Because of the mobility aspects of the facility, some transportation requirements may be involved after methods have been determined.

Transport

As has been stated, the medical emergency facilities will be located throughout the world in order to be as close as possilbe to potential disaster regions. Because of the variety of terrains in these regions and because of advanced or underdeveloped technological conditions, a variety of transportation sources may be needed.

Air travel would be the most direct means of transportation, but conditions may be such that air travel is impossible or impractical. Specific means of air transport should be studied, however, including airplane, dirigible, and helicopter. Land and water transport may be necessary in some cases, or a combination of any or all of these means of transport.

images

Images

Although providing an image producing facility is not the primary goal of this study, it is nevertheless quite important. Situated in a disaster area, the medical facility should provide a spark of hope for those bereaving the loss of friends and damage of property. It may be the only visual element of stability and organization in the disaster area. The facility should also be read as a professional medical center and should carry no connotations of "first aid." It is vital that the disaster casualties and others involved in rescue procedures have confidence in the aid being offered in the center.

Within the facility itself, it is important to carry out these same themes. Casualties are distraught enough just realizing that they have been injured. As much as possible, the structure and personnel should provide a clean, comfortable, but highly efficient operation.

bibliography

BIBLIOGRAPHY

American College of Surgeons, Committee on Trauma, Guidelines for Design and Function of a Hospital Emergency Department, Chicago, Ill., 1970.

American Hospital Association, Disaster Management, Chicago, Ill., 1971.

American Hospital Association, Principles of Disaster Preparedness for Hospitals, Chicago, Ill., 1956.

American National Red Cross, Disaster Handbook for Physicians and Nurses, Washington, D.C., 1966.

Cornell University Medical College - U.S. Public Health Service, The Treatment of Mass Civilian Casualties in a National Emergency, Washington, D.C., 1967.

Dynes, Russel, R., Organized Behavior in Disaster, Washington, D.C., Heath Lexington Books, 1970.

Elias, Houghton F., "Management of Mass Civilian Casualties," Nebraska State Medical Journal, 54, Jan., 1969, pp. 3-5.

Fairley, James, "Mass Disaster Schemes," British Medical Journel, 4, Nov. 29, 1969, pp. 551-3.

Holloway, Ronald M., "Mobile Vans As Disaster Scene Emergency Rooms," Hospitals, J.A.H.A., 46, Dec 1, 1972, pp. 43-47.

Hunt, Thomas R., "Triage," Arizona Medicine, 26, Feb. 1969, pp. 139-40.

Kroger, E. K., "Proposal for an International Disaster Center," Health Services Report, 88, Jan. 1973, pp. 23-30.

Mustell, Peter, "Correspondence," New England Journal of Medicine, 285, July. 1971, p. 125.

Rosenfield, Isadore, Hospital Architecture-Integrated Components, New York, Van Nostrand Reinhold Co., 1971.

U.S. Dept. of Commerce, Earthquake Information Bullitin, Vol. 2, Nov-Dec., 1970.

U.S. Dept. of Health, Education and Welfare, Public Health Service, Div. of Health Mobilization, Central Sterile Supply Section of the Packaged Disaster Hospital, Washington, D.C., 1966.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, Checklist for Developing a Packaged Disaster Hospital Readiness Plan, Washington D.C., 1965.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, Community Emergency Health Preparedness, Washington, D.C., 1964.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, Establishing the Packaged Disaster Hospital, Washington, D.C., 1966.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, Hospital Planning for National Disaster, Washington, D.C., 1968.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Emergency Health Services, Packaged Disaster Hospital, Series 10000 Mod "A", Component Listing and Storage Data, Washington, D.C., 1969.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, The Role of the Dentist in National Disaster, Washington, D.C., 1965.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, The Role of the Nurse in National Disaster, Washington, D.C., 1965.

U.S. Dept. of Health, Education, and Welfare, Public Health Service, Div. of Health Mobilization, X-Ray Section of the Packaged Disaster Hospital, Washington, D.C., 1966.

Wheeler, E. Todd, Hospital Design and Function, New York, McGraw Hill Book Co., 1964.

design proposal

DESIGN JUSTIFICATION AND EXPLANATION

In writing an explanation of the facility which I have proposed, I will cover four main points of view;

(1) a disaster relief team official in Lima Peru

(2) an engineer helping to establish the facility

(3) a casualty processed within the facility

(4) a physician working within the facility.

By taking these varied points of view, I intend to justify a variety of design decisions which I made while designing the facility.

A Relief Team Official in Lima Peru

After our regional disaster center in Lima was notified that there had been an earthquake in Guayaquil, Ecuador, our team of experts was immediately briefed on the situation and transported to the site for an initial reconaissance. Within 24 hours after the first shock, we received a first report of the situation and notified Quito and other surrounding areas. Our central coordination office in Geneva was also briefed on the situation. The team of experts continued

correspondence from the site, requesting an air-drop as soon as possible. They specified the items which were to be included in the drop.

The quake ripped right through the center of Guayaquil during business hours and left the city in a pile of rubble. Several explosions and subsequent fires added to the confusion and bodies were scattered everywhere. Those fortunate few survivors wandered aimlessly through the rubble in a state of shock and disbelief. Anguish and pain was everywhere. At several points throughout the city, ruptured pipes were spewing raw sewage into craters formed by the debris. The stinch was present everywhere.

By this time the field experts had organized a central disaster office in the area and supplies were on the way. The modular disaster hospital was one of the first relief units to be sent.

This basic medical unit is comprised of pneumatic ribbed structures fastened to an elevated hexagonal deck, transported in a folded position. The package is flanked on either side by two fiberglass units; one being jack storage and the other a toilet module. The units are relatively light weight, weighing approximately 2500 pounds each (weight includes pneumatic structure). They form the exterior shell for a 200 bed hospital. The units are quite

economical and flexible enough to respond to any situation, at almost any location, in any climate. These variations can be accomodated by changing basic elements, a relatively simple operation.

This modular facility, along with the other requested medical supplies food and earthmoving equipment was air-dropped near a soccer field on the outskirts of Guayaquil. The soccer field was selected by the reconaissance team for the location of the disaster hospital because of its large open area and proximity to the disaster site.

All of this had been accomplished in about 48 hours. Within all the confusion, small pockets of organization soon began to appear, as more aid filtered into the area.

An Engineer Helping to Establish the Facility

We were air-dropped near the soccer field on the outskirts of Guayaquil before the other supplies arrived. There we met with the reconaissance team and were briefed on the configuration which the hospital was to take. In their initial report the team had already determined what medical supplies were needed and how they should be injected into the hospital to obtain the most efficient medical operations. It was our job to recruit help and assemble the hospital

to those specifications.

The air-drop followed shortly after our meeting with the reconaissance team. We had no trouble locating the 24 packages because of their bright orange and white color. However, the toilet module on one package was slightly damaged when the package rolled over and crashed to the ground after landing in a tree. At this time a helicopter had not yet reached the disaster site so we employed a small lift obtained from a nearby factory and loaded the packaged units onto flat bed trucks. Six units fit easily on each flat bed truck.

After all the structural packages had been collected, they were carried onto the soccer field where they were unloaded and disassembled. The jacks and crossbracing were first retrieved from the fiberglass end shells. We used a surveyor's level to position and level the jacks, forming a grid on the soccer field. For lateral support we attached the adjustable cross braces producing a rigid frame on which to place the decking. As quickly as we could assemble the understructure, the folded decks were positioned and unfolded to their maximum area of 672 square feet. The decking is comprised of 8' triangular panels hinged together in such a way that they can be folded into an area of only 84 square feet (e.g. while packed). The deck is attached to the jacks with

attachment plates.

Working closely with us while we were assembling the understructure was a crew running flexible pipe to all the areas where it was needed for carrying water. Another group was making all the electrical hookups.

The city's power had been knocked out by the quake and therefore the 15 KW auxillary generator had to be used to generate electrical power. We were afraid to tap the water lines running through the area for fear they might have been contaminated. To remedy this situation we erected a 1500 gallon pole mounted water storage bag and started pumping it full of water. All the water being used was brought in during subsequent air-drops. Later on we had to erect another bag to meet the increasing water demands.

Having made all the electrical and plumbing hook-up, and having erected all the decking in the proper configuration, we were prepared to attach and inflate the pneumatics, which were still folded. We unfolded the tents and centered them properly on the decking. The aluminum tubing at their base was bolted directly into the particle board/foam board structural deck.

The pneumatic structures are made of vinyl coated nylon. At the apex of each unit there is a vent.

After attaching the structure, a mobile compressor was used to inflate

the structural ribs. An automatic shut-off valve in the air line keeps the ribs from over inflating.

Since the weather in Guayaquil is relatively mild the reconaissance team decided to use as much fresh air flow as possible. We achieved this by attaching snap on windows at all points where there was not a structure to structure passage planned. The passages between tents were also snapped together forming larger spaces.

Each one of the tents has six possible connection points. These openings can be either closed completely, screened, or joined to other units forming a passage. Also included in the package are door units which can be snapped into place.

The toilet units mentioned earlier as part of the package are located around the periphery of the facility. They too are attached to one of the six opening on each of the modules. These units, after being attached, are connected to plumbing and electrical lines. A compartment in the rear of these units contains a small electric hot water heater along with an auxillary air conditioning and heating unit. The air conditioners were not used in Guayaquil but in other climatic conditions they would have been activated. In extreme hot

or cold situations it is possible to arrange the facility so that every pneumatic tent has conditioned air ducted directly into it.

A shower unit is also available which has the same connections and physical form.

Another of these units contains accessories for an operating theater. Besides the air conditioning, it contains a vacuum pump and hook-ups to oxygen, nitrogen and compressed air tanks. These services feed into the operating areas by means of bus duct traveling along the floor. The surgical module also contains a scrub-up sink, sterilizer and storage for instruments.

We assembled all of these elements as directed by technical and medical advisors and in another 24 hours the facility was ready for occupation.

Several days after the facility had been established we had heavy rains in the area. The soccer field got pretty soggy, forming two inch deep puddles in places. Because of the jacking arrangement and integral vinyl coated nylon flooring in the modules, the work areas stayed completely dry.

While the facility was being established, a work crew was busy opening a major road to the soccer field and locating exterior mercury vapor lamps around the facility for night time illumination. Supplies began to flow in.

Casualties, many who had been given first aid already also started flowing in.

A Casualty Processed Within the Facility

I was shopping for groceries in downtown Guayaquil when the earthquake hit. It sounded like a bomb had gone off and before I had a chance to react I found myself lying in a pile of debris. People were screaming all around me. A large chunk of concrete lay across my leg immobilizing me. The pain in my leg was more then I could bear. I couldn't even move. I guess I passed out for a time in shock. The next day I awoke with the sun shining in my eyes. Someone had moved me out into the street and had splinted my leg. The pain was still there, however. A nice man brought me water and told me that a field hospital was being prepared nearby. The general hospital in Guayaquil was damaged and could not handle all of those seeking admittance. Only extreme cases were being admitted.

I remember the next day being loaded into a small car. The ride was rough and the orange and white canopy at the field hospital was a welcome sight.

I was carried up a ramp and into the facility. There were already crowds of people standing around, many of them mournfully sobbing.

I was carried through a series of white translucent domes to an x-ray area and then on to an area containing about 18 other people all lying on cots.

The noise had diminished and I felt more relaxed.

That evening, a plastic cast was put on my leg, and the next day I left the facility and went to an area where some of the same type structures had been established for temporary housing. The neat white domes sharpely contrasted the surrounding destruction and gave a ray of hope to the situation.

A Physician Working Within the Facility

I was air-dropped near the soccer field after the facility had already been established. Patients had been flowing through the facility for some time.

I was first directed to the staff quartering area, a structure identical to that of the hospital. There we were briefed on the situation and given assignments in the facility.

I was assigned to an area where fractures were being treated, one of the busiest areas in the hospital.

Supplies were brought into the area on mobile carts and stored in one of the out of the way pockets in the ward. The sunlight, diffused by the white dome provided perfect lighting during the day time. At night there were plenty of standard mounted lights to illuminate the ward. The flooring was light green relaxing our vision which was constantly being strained by the sight of blood.

Throughout the facility, bold graphics introduced the various areas, adding a cheery touch to the sterile environment.

After a few days we decided to close one of the connectors leading into our ward. The traffic flow was causing congestion. It was quite simple to unsnap the unit connector and in its place snap in a screened window. The result was also favorable in that we had better air circulation in our ward.

The electrical outlets located every eight feet were immensely useful with all the mobile power equipment we were using.

I worked the day time shift in a two shift operation, keeping the facility operating 24 hours daily.

The facility remained for about nine months after its initiation. Functions and priorities changed over this period of time. The general hospital in Guayaquil was repaired and it was once again able to handle the load of patients.