CHAPTER ONE

INTRODUCTION

Introduction

1.1 Over view:

An emergency hospital is a medical treatment facility specializing in acute care of patients who present without prior appointment, either by their own means or by ambulance (critical cases). The emergency department is usually found in a hospital or other primary care centre.

Due to the unplanned nature of patient attendance, the department must provide initial treatment for a broad spectrum of illnesses and injuries, some of which may be life-threatening and require immediate attention. In some countries, emergency departments have become important entry points for those without other means of access to medical care.

The emergency departments of most hospitals operate 24 hours a day, although staffing levels may be varied in an attempt to reflect patient volume.

1.2 Problem:

The main problem of this thesis is the lack of the specialist emergency facilities in our country, and the inefficiency of the emergency department in most of the country's hospitals, particularly public hospitals.

1.3 Objectives:

1.3.1 General objective:

Design an ideal emergency facility help to provide treatment to those in need of urgent medical care, with the goal of satisfactorily treating the presenting conditions, or arranging for timely removal of the patient to the next point of definitive care.

The term emergency medical service evolved to reflect a change from a simple system of ambulances providing only transportation, to a system in which actual medical care is given on scene and during transport.

Most emergency medical services are to decrease the accidental death and almost availability of the professional staff as well as doctors, nurses and technicians were trained on the speed in the quality of performance to achieve the immediate rescue.

Also, help to reduce the aggravation of problems, sudden and perhaps final treatment.

1.3.2 Specific objectives:

The s Specific objectives to mainstream the term of emergency needed and services in our community.

Also, connect the biomedical engineering domain with the science of hospital design by applying all medical, theoretical and geometrical education and science that learned in whole years of study.

1.4 Methodology:

To design an ideal emergency facility, a very important steps was followed carefully:

1. Data collection
2. Data analysis
3. Design

1.5 Thesis Layout:

This thesis consists of six chapters:

Chapter one illustrates a brief introduction and general view about the project. Chapter two containing theoretical foundation and previous study in emergency hospital or department designed during the last years. In chapter three discusses the methodology of data that collected about the situation manner of emergency departments in Khartoum state, and analyze these data to get a best result.

The design considerations and guideline of emergency facility has been described in chapter four, including the final design plane and lay out. The result and recommendations of this work devoted in chapter five and six respectively.

Theoretical Fundamental

2.1 Literature review:

For general literature some terms must be defined

2.1.1 Hospital definition:

Hospital is a facility that contains medical devices for diagnoses therapy or rehabilitation, and also contains beds for inpatient and medical services include continued physicians and nurse's services to provide the diagnosis and therapy for patient.
A hospital is a health care institution providing patient treatment with specialized staff and equipment [1]

2.1.2 Types of hospitals:

There are five types of hospital defined as follow:

2. 1.2.1 General hospital:

The best-known type of hospital is the general hospital, which is set up to deal with many kinds of disease and injury, and normally has an emergency department to deal with immediate and urgent threats to health. Larger cities may have several hospitals of varying sizes and facilities [1].

2.1.2.2 District hospital:

A district hospital typically is the major health care facility in its region, with large numbers of beds for intensive care and long-term care [1].

2.1.2.3 Specialized hospital:

Types of specialised hospitals include trauma centres, rehabilitation hospitals, children's hospitals, seniors' (geriatric) hospitals, and hospitals for dealing with specific medical needs such as psychiatric problems (see psychiatric hospital), certain disease categories such as cardiac, oncology, or orthopaedic problems, and so forth.
Specialised hospitals can help reduce health care costs compared to general hospitals [2]

2.1.2.4 Teaching hospital

A teaching hospital combines assistance to people with teaching to medical students and nurses and often is linked to a medical school, nursing school or university. In some countries like UK exists the clinical attachment system that is defined as a period of time when a doctor is attached to a named supervisor in a clinical unit, with the broad aims of observing clinical practice in the UK and the role of doctors and other healthcare professionals in the National Health Service (NHS) [2].

2.1.2.5 Clinics

The medical facility smaller than a hospital is generally called a clinic, and often is run by a government agency for health services or a private partnership of physicians (in nations where private practise is allowed). Clinics generally provide only outpatient services [2].

2.1.3 Levels of Care

According to the models that supported by world health organization (WHO) the level of care may classified as follow:

1. Family and home.
2. Community health activity.
3. First health facility (sub-district).
4. First referred level (district).
5. Second referred level (Provincial).
6. Third referred level (National).
7. High referred level.

2.1.4 Team of work

Teamwork is important in providing high-quality hospital care including Physicians, nurses, and other healthcare professionals spend a great deal of their time on communication and coordination of care activities.

A team is defined as two or more individuals with specified roles interacting adaptively, interdependently, and dynamically toward a shared and common goal.
Elements of effective teamwork have been identified through research conducted in aviation, the military, and more recently, healthcare. Salas and colleagues have synthesized this research into five core components: team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation.

Several important and unique barriers to teamwork exist in hospitals. On a given day, a patient's hospital team might include a hospitalist, a nurse, a case manager, a pharmacist, and one or more consulting physicians and therapists. Team members in each respective discipline care for multiple patients at the same time, yet few hospitals align team membership [3].

2.1.5 Hospital planning fields:

Study the health needs of the surrounding community and expected to benefit from the various hospital services with the study of any obstacles that could face the establishment of this service and to find appropriate solutions.

The important planning point can be displayed as follow

1. Coordination between the various operational units in the hospital to ensure proper implementation of the operational plan for the hospital.
2. Development of specifications and standards for measuring the performance of the services provided by hospital.
3. Development of specifications for buildings, equipment and devices that must be met**.**

4. Define General budget of hospital which consists of the total detailed budget in various operational units and departments [1].

2.1.5.1 Determining the service area

The first step in any planning or marketing project for a hospital provider is to define a service area. Before demographics or market share can be run, an appropriate service area must be applied. Defining a service area is both art and science [4].

2.1.6 General construction features and hospital plans

1. Solar radiation (e.g., wall shading by generous roof overhang).
2. Ventilation.
3. Terrain features (e.g., tress for shading).
4. Pests (Protection of electrical wiring against rodents).

All hospital facilities should be capable of continued operation during and after a natural disaster, except in instances where a facility sustains primary impact. This means that special design consideration is needed for the protection of essential services such as emergency power generation, heating systems, water (if applicable), etc. Typical problems such as disruption to the Minister's water or sewer mains and energy supplies, may affect the operation of on-site services. However, the responsibility for maintaining these public utilities lies with others [5].

2.2. Back ground studies:

- Wiinamaki et al (2003), Simulate an architecture phase of an emergency department aimed to determine and analyse the required equipment and there expansion area, they used macro and micro level [6].
- Frank Zilm et al (1990), target on the basic question for the emergency planning; is the trade-off between assuring quick patient access to treatment and the operational and facilities cost requirements to meet peak-demand periods. One dimension of this problem is quantifiable — estimating peak demand and resulting bed needs. Determining the

acceptable level of delays is a function of the patient mix as well as the institution's values, strategic vision and resources. His studies concerned on the space, implication, topologies, and safety. A useful model for the analysis of such complex services as emergency care is Eliyahu Goldratt's "Theory of Constraints.

In the case of emergency departments (EDs), designers look for factors that affect the processing and movement of patients. From a facility perspective, they should seek to identify the physical resources, particularly treatment spaces. If successful, designers will identify the minimum building resources to assure that space is not the constraining variable. Designers need to understand the demand during peak periods and then determine the required resources. The problem typically is divided into two components:

1. Analysis of the external variables that create demand that are not in control of the ED.
2. Assessment of the internal operational processes and resources that is available to respond to the demand.

External components that should be included in the projection of demand include population demographics, utilization patterns, market share characteristics, anticipated health care policies and the strategic vision of the institution [7].

- Mike Plotnick in (2015) Healthcare Facilities, The design of an efficient Emergency Department in which care is coordinated and carried out in an appropriate environment depends on the productive collaboration between a number of key stakeholders involved in the building or redevelopment process. The process of Emergency Department design should consider:

1. Functionality – an Emergency Department’s design needs to be practical and reflect how health professionals manage and treat their patients who have different clinical conditions.

2. Form – spatial considerations and relationships that promote effective interaction between staff and patients, relatives, carers, and the flow of clinical care. Consideration that Emergency Department models of care will change over time is needed, as well as consideration of the relationship between the Emergency Department and the greater hospital. Over time, clinical treatment spaces will be reallocated, so many spaces need to have flexibility built into them to ensure future proofing.

Patient and staff needs – the aim of health care is not only to treat disease, but also to create a healing environment for patients that is safe and free of psychosocial elements created through poor design. Additionally, the workplace needs for Emergency Department staff can be promoted through the application of Occupational Health and Safety (OH&S) standards that ensure a work environment that is as safe as possible. The psychosocial wellbeing of staff should be considered through design and space use. This should not be underestimated given that staff will occupy the Emergency Department spaces much longer than any patient, relative or carer [8].

CHAPTER THREE

METHODOLOGY AND DATA ANALYSIS

Methodology and Data Analysis

3.1 Introduction:

In this chapter outlines the general methodology of the study, the data analysis and the questionnaire procedures used.

To design ideal emergency facility (EF) we must first study the situation of some emergency departments (ED) in our local hospitals and study the current design.

3.2. Methodology:

The questionnaire was used to illustrate the lake present in those hospitals, whether in terms of location, building, instruments or staff education & training.

— **1.** First step was a study the current designs in the local hospitals through primary data collection by questionnaire illustrates the real problems and the lake present in those hospitals, whether in terms of location, building, instruments or staff education & training.

— **2.** Second step was data analysis that employs both descriptive and analytical statistics, which was done by a statistician using computer-based program Statistical Package for Social Sciences (SPSS).

— The aim of this step is to focus on the weakness in current emergency departments and treat it through the ideal design.

— **3.** Finally and according to international standard of hospital design, the 3D model for complete facility departments was designed.

3.3 Survey Field:

The field of these survey the emergency room staff either doctors, nurses and medical administration. The criteria of this study included the emergency room area, medical devices evaluation, staff and training and patient services. The field survey was used to identify problems and issues of ED, there were 25 persons who participated in the interview.

3.4 Survey and analysis details:

3.4.1 Study duration:

A period of two months (from Jan 2015 to Mar 2015)

3.4.2 Study sampling:

Forms were filled through personal interviews with the official responsible for ED at each hospital. The form contained 11 items and was administered to the health care establishments, 1 at each hospital

3.4.3 Sampling techniques:

Non probability convenience sampling was used to recruit participants according to the following inclusion and exclusion criteria:

3.4.4 Data collection techniques and tools:

The interviews guided by questionnaires

Questionnaires are composed of 11 questions to evaluate the quality of ED in the general hospitals, such questions prepared in accordance with the observation statistical standards for easy to understand and answer questions in a scientific and comprehensive (See Appendix A).

3.4.5 Data analysis:

Data analysis emblements both descriptive and analytical statistics, which was done by a statistician using computer-based program Statistical Package for Social Sciences (SPSS) version 21.

3.4.6 Ethical considerations:

1. A written informed consent from the university was obtained.
2. The study was approved by the university ethical review board (ERB).
3. A verbal informed consent was obtained from the participants.
4. The participant confidentiality will be conserved.

3.5 Data Analysis:

3.5.1 Represents area of ED

Through the study and analyses we found that 32% of sample study says there's represents area of ED and 68% of the sample study says No the table and figure (3.1) showing below:

Table (3.1): Represents area of ED abunduce

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	8	32.0	32.0	32.0
	NO	17	68.0	68.0	100.0
	Total	25	100.0	100.0	

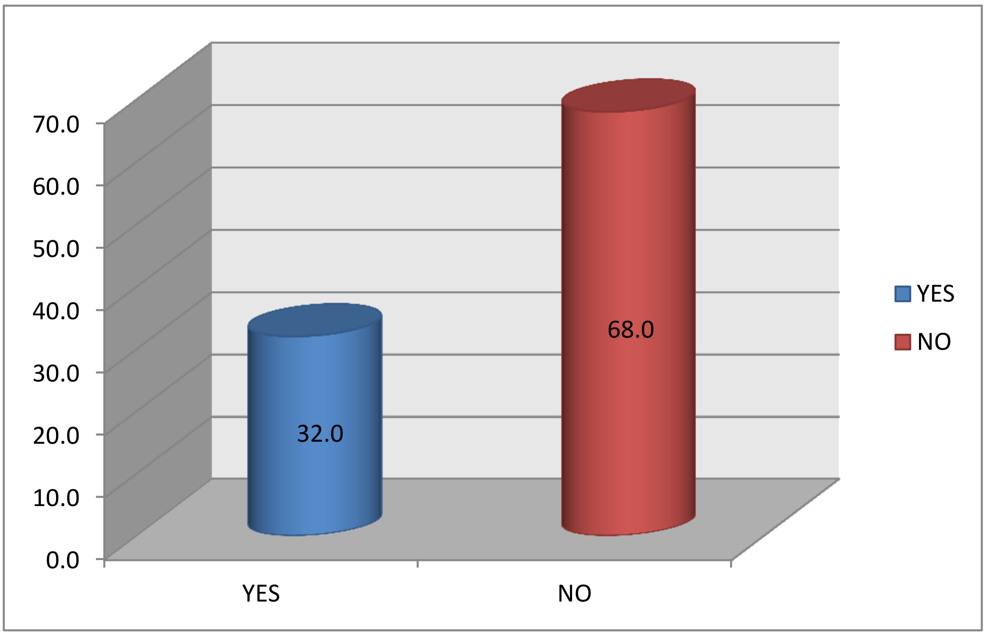

Figure (3.1) represents area of ED abunduce

The majority of sample study was 68%, so we found the most hospital have small area for the ED and that definitly leade to patient congestion in case of accedents and critical situations.

3.5.2 Evaluation of patient present to ED

80% of sample study evaluation of patient present to ED are private , and 20% of the sample study ambulances, the table(3.2) and figure (3.2) showing that below :

Table (3.2) the patient present to ED

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Private	20	80.0	80.0	80.0
	Ambulances	5	20.0	20.0	100.0
	Total	25	100.0	100.0	

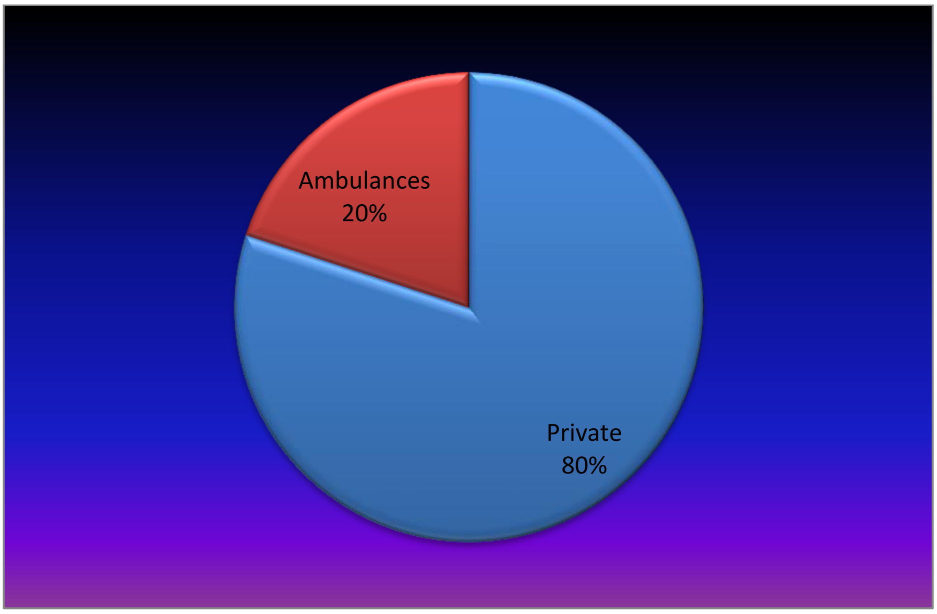

Figure (3.2) the patient present to ED

The result were 80% of patient present by private way and these is very high percentage because the emergency cases linked with present of ambulance for 24 hours.

3.5.3 The number of ambulance used by ED

The study showing that, 64% of hospital with range from 1 to3 ambulance available not only for ED but for all other hospital departments, 8% in range of 4-7 and that founded only in private hospitals, 0% for more than 7, and 28% for no ambulances founded in all hospital.

Table (3.3) the number of ambulance used by ED

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-3	16	64.0	64.0	64.0
	4-7	2	8.0	8.0	72.0
	No Ambulance	7	28.0	28.0	100.0
	Total	25	100.0	100.0	

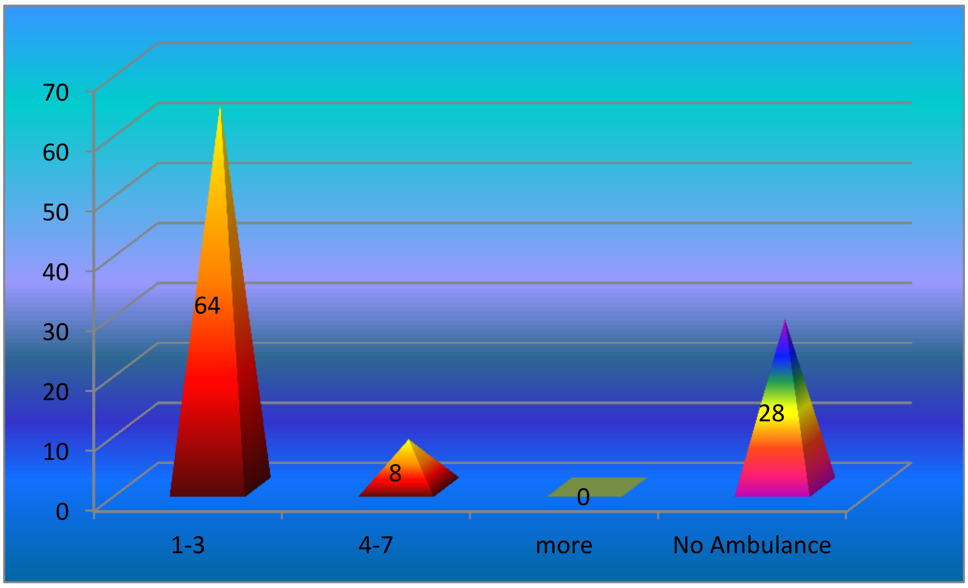

Figure (3.3): The number of ambulance used by ED

The important point in this section the decision of the ministry of health to remove all ambulance from the governmental hospitals and that to create a central ambulance for all state, and this decision may lead to elevate the load on that centre.

3.5.4 The patients that transform to other ED

Table (3.4) and figure(3.4) showing the percentage of patient that transform to other hospitals before treatment, 20% of hospital answer by no patient was transformed , and 68% of hospitals transform about 25%

of their patient daily , also no one answer by 50% or 100% and final 12% transform about 75% of patient to other ED.

Table (3.4) The patients that transform to other ED without treatment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0%	5	20.0	20.0	20.0
	25%	17	68.0	68.0	88.0
	50%	0	0.0	0.0	88.0
	75%	3	12.0	12.0	100.0
	100%	0	0.0	0.0	0.0
	Total	25	100.0	100.0	

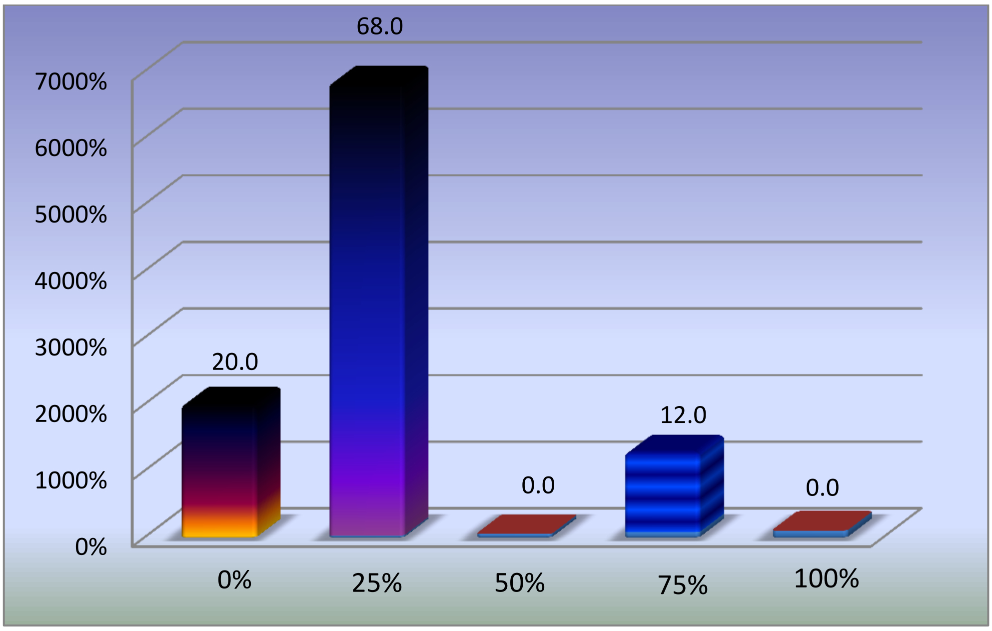

Figure (3.4) the patients that transform to other ED

Through this question there are hospitals never transformed their patient and that for two reasons:

Some hospitals get general administration decision to prevent the transfer of patient, even if the hospital cannot provide the necessary services, and that may not explained decision.

The other reason is the refusal of some hospitals to receive cases referred from other hospitals, and these refuse also not explained.

3.5.5 The unavailability of biomedical devices or other medical needs

Throw the study and analysis we found that 28% saying yes for the shortage in biomedical devices or other medical needs availability and 72% saying no the table and figure (3.4) showing that below:

Table (3.5) The unavailability of biomedical devices or other medical needs

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	7	28.0	28.0	28.0
	NO	18	72.0	72.0	100.0
	Total	25	100.0	100.0	

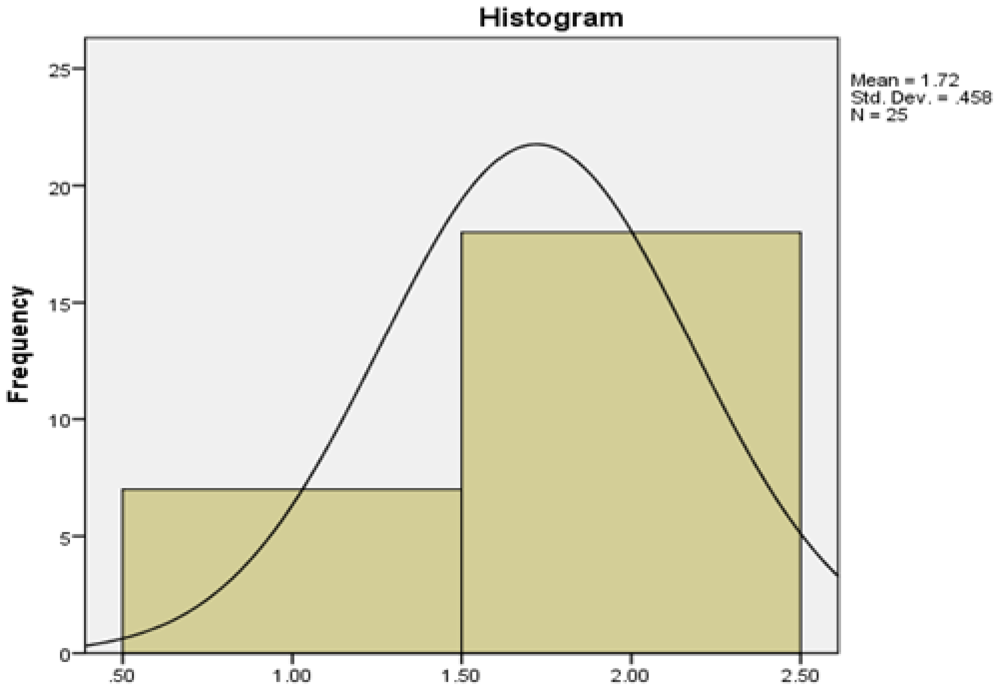

Figure (3.5) the problems in biomedical devices or other medical needs availability

This Section to evaluate the ED in terms of consumable and medical devices that represent in figure (3.5), 72% answer with no permanent shortage, and all shortages resolved immediately by the biomedical engineering department, but also there is 26.1% answer they have problems and it is not resolve for a while, the next section represent the reasons.

3.5.6 The medical devices maintenance evaluation

represent the reasons of lake in medical devices maintenance, 28% because the spare part is not available in a local market, 16% because of high cost of spare part or maintenance in case of contract services, in other hand the 8% do not have biomedical engineering BME and 48% for no problems. Table (3.6) and figure (3.6) showing that below:

Table (3.6) the medical devices maintenance evaluation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No problems	12	48.0	48.0	48.0
	Spare parts Not Available	7	28.0	28.0	76.0
	High Cost	4	16.0	16.0	92.0
	Don't have BME	2	8.0	8.0	100.0
	Total	25	100.0	100.0	

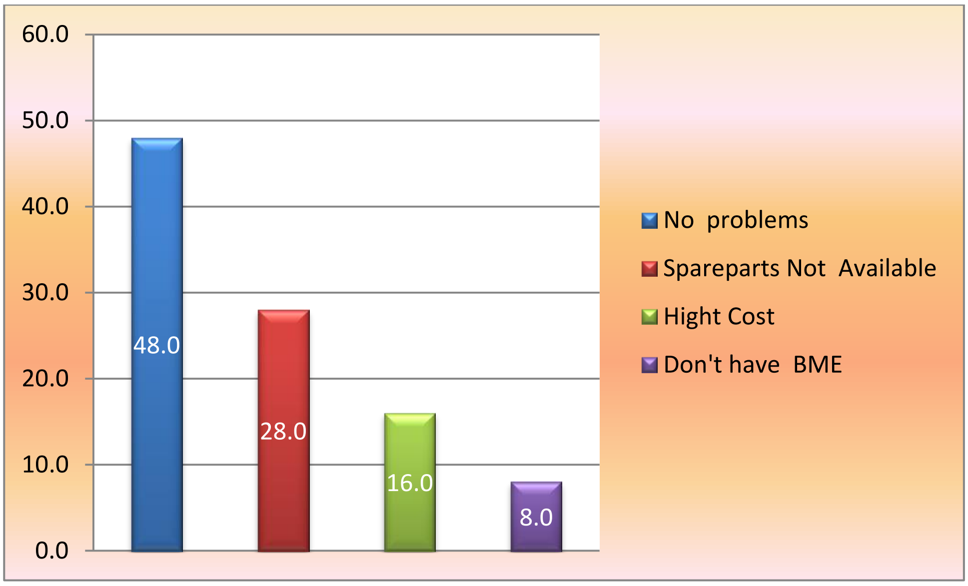

Figure (3.6): the medical devices maintenance evaluation

3.5.7 The availability of medical trained staff in ED

The evaluation of trained staff of ED represent in table (3.7) and figure (3.7), 64% answered there is no enough trained staff, and these one of most important point in emergency hospitals design these staff must be trained on speed in handling the different patient situation. Table and figure (3.7) showing that:

Table (3.7) the availability of medical trained staff in ED

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	9	36.0	36.0	36.0
	NO	16	64.0	64.0	100.0
	Total	25	100.0	100.0	

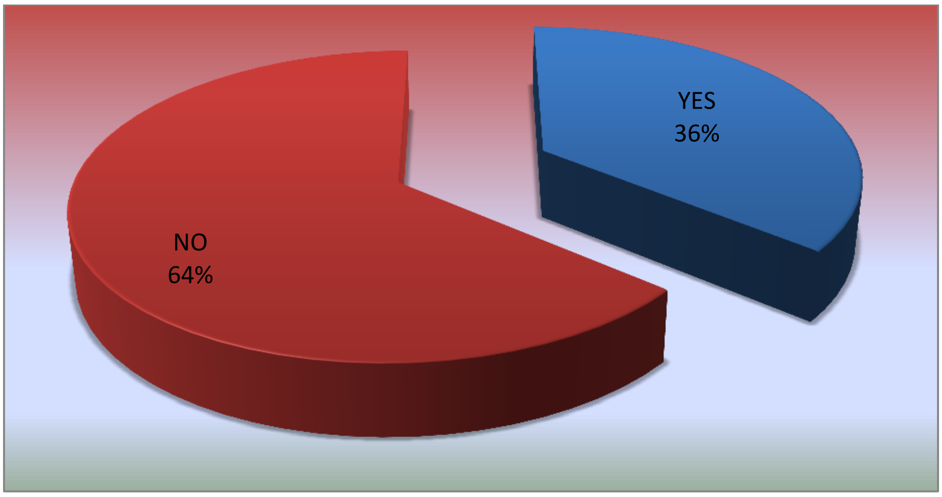

Figure (3.7) the availability of medical trained staff in ED

3.5.8 Needs to redesign of ED

The analysis found that to evaluate the ED both in organizational terms or design term, the answer percentage, 80% of hospitals both in governmental and private answer the department need to redesign and some of these hospitals also need to reorganize either in increasing the number of beds or by identify and distribute the work between staff members. Figure (3.8) and table (3.8) shows that.

Table (3.8) Needs to redesign of ED

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	20	80.0	80.0	80.0
	NO	5	20.0	20.0	100.0
	Total	25	100.0	100.0	

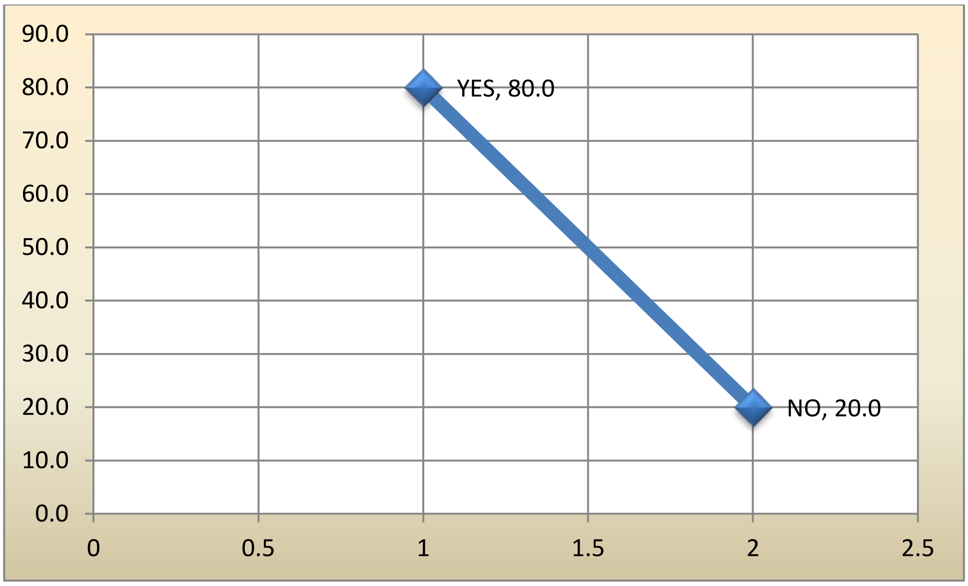

Figure (3.8) needs to redesign of ED

3.5.9 Separate the ED as independent hospital

These analysis is the most important question that "do you think the ER department can be more useful and more effective if separated as independent hospital", the answer of these question shows in figure (3.9), 92% think so, and only 8% don't think that, these small percentage result from obstetrics and gynaecology hospital staff, they think the emergency of OBS must linked with all hospital department and that for some special cases. Table and carve showing that below:

Table (3.9) Separate the ED as independent hospital

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	23	92.0	92.0	92.0
	NO	2	8.0	8.0	100.0
	Total	25	100.0	100.0	

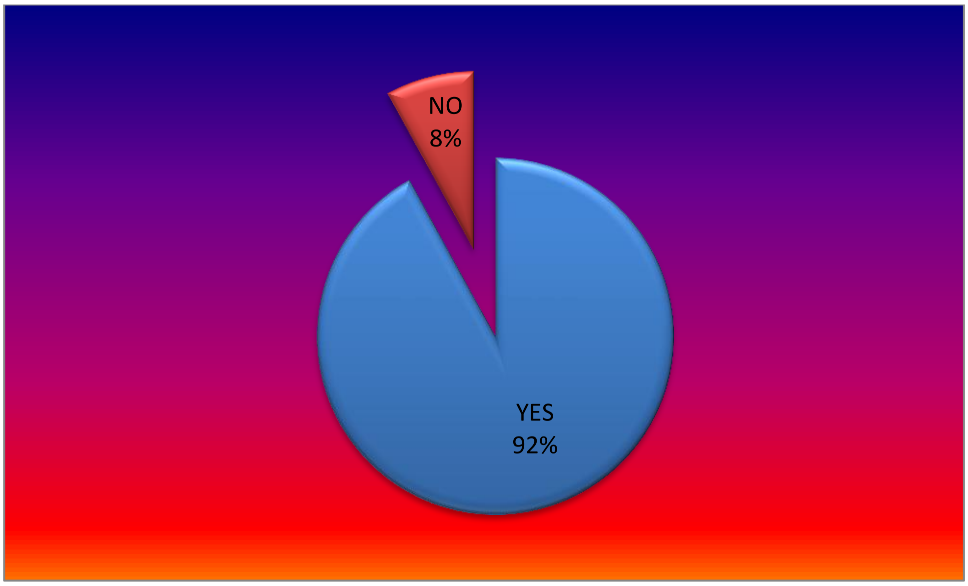

Figure (3.9) separate the ED as independent hospital

3.6 Relations:

In this study the evaluation of relation between two variables must be provided, the variable selected as below

1. ED can be more useful and effective if separated as independent hospital
2. The patients that transform to other ED without treatment.

Table (3.10) correlation between separate the ED as independent hospital and transform the patient before treatment to other hospital using Pearson Correlation

		Separate the ED as independent hospital	The patients that transform to other ER department
Separate the ED as independent hospital	Pearson Correlation	1	.344
	Sig. (2-tailed)		.093
	N	25	25
The patients that transform to other ED without treatment	Pearson Correlation	.344	1
	Sig. (2-tailed)	.093	
	N	25	25

By measuring the Pearson correlation we find that there is a relationship between two variables degree of freedom which is 0.93 higher than the 0.05 level measurement of any two-way relationship, so we reject the hypothesis of non-acceptance and accept the hypothesis which states that the existence of a specialized hospital is reduced the number patients that transform to other ED.

1. **The abundance of ED area**
2. **The patients that transform to other ED before treatment**

Table (3.11) Correlation between The abundance of ED area and transform patients to other ED before treatment using Pearson Correlation.

		The abundance of ED area	The patients that transform to other ER department
The abundance of ED area	Pearson Correlation	1	.242
	Sig. (2-tailed)		.245
	N	25	25
The patients that transform to other ER department	Pearson Correlation	.242	1
	Sig. (2-tailed)	.245	
	N	25	25

By measuring the Pearson and Spearman correlation we find that there is a relationship between two variables degree of freedom which is 0.332 higher than the 0.05 level measurement of any two-way relationship, so we reject the hypothesis of non-acceptance and accept the hypothesis which states that the Represents area of ER is reduced the patients that transform to other ED.

3.7 Questionnaire's analysis

Through analysis and study, we found that there are several problems in public hospitals can be summarized as follows:

1. There are amount of patients transferred from public hospitals to other hospitals without treatment or first aid.
2. Most hospitals didn't have sufficient number of equipped ambulance.
3. Insufficiency of medical devices on ED on some hospitals
4. Unavailability of trained medical staff in public hospitals to provide the best emergency services and medical care.

CHAPTER FOUR

EMERGENCY FACILITY DESIGN

Design of Emergency Facility

4.1 Introduction:

The Department of Health has published planning and design guidance for accident and emergency departments. Building a new department or refurbishing an existing one happens rarely but when it does, it provides the opportunity to design a modern department that inspires and intuitively supports effective, efficient and safe patient care, with the flexibility to meet future developments in healthcare, technology and patient volumes [9].

This guidance provides information on how to approach a new build or redesign, specifically aimed at senior emergency clinicians and designers so key to making a new build successful. It aims to facilitate purposeful dialogue between those responsible for service delivery and those responsible for design response [9].

Delivering a new emergency hospital is not just about design; there are three other key components crucial to the success of a new build or refurbishment: processes, communication and the ability to change [9], see figure (4.1).

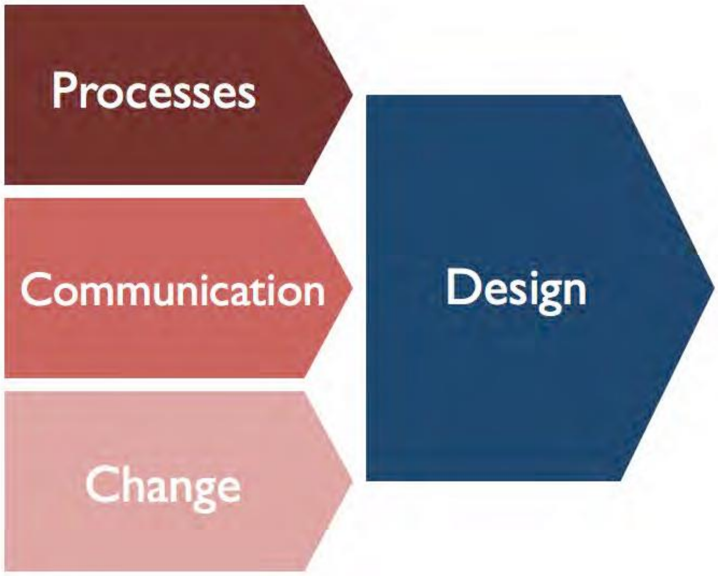

Figure (4.1) four key components of success

All processes used within the emergency hospital need to be effective and efficient in delivering the service so that the new design will support their use. A new design will not improve the delivery of emergency care or be viewed as successful if the processes in use are out-dated or inefficient.

There are strong remarkable depute between the dynamic change of practices, activities, equipment, regulations and standards,and on the other, the idea of fixed stable, innovative environments and established budgets [9].

4.2 Design guidence:

The aim of this design guidance at the inception of a project and in its development is to signpost a route through best practices, tools and techniques that can be used and adapted by the wider design team. It offers insights into activity analysis, decision-making and project programming [12].

A good emergency care is:

- Patient-focused.
- Delivers excellent clinical outcomes (including survival, recovery, and lack of adverse events or complications).

- Delivers a good patient experience (easy to access, convenient and cared for in an appropriate environment).
- Timely and consistent.
- Right first time.
- Available 24 hours, 7 days per week, 365 days a year [9].

4.2.1 Hospital Information System (HIS):

The information and communication strategy (ICT) for emergency hospital will need to be developed as part of the integrated design. This includes:

1. Patient registration.
2. Record of visits.
3. Results from tests.
4. Discharge or handover documentation.
5. How patient records are accessed and shared.
6. How re-stocking is managed.
7. How performance is measured, recorded and shared.
8. How movement of equipment or patients and staff is recorded.
9. How visual information is displayed (such as waiting times to patients, critical information to clinical teams) [9].

4.3. Common elements for emergency facilities

Emergency care may range from the suturing of lacerations to full-scale emergency medical procedures. Facilities that include personnel and equipment for support emergency care should provide for 24-hour service and complete emergency care leading to discharge to the patient's home or direct admission to the appropriate hospital [12].

4.4. Initial Emergency Management

Initial emergency management is care provided to stabilize a patient's condition and to minimize potential for further injury during transport to an appropriate service. Patients may be brought to the nearest hospital, which may or may not have all required services for definitive emergency management.

It is important that the hospital, in those cases, be able to assess and stabilize emergent illnesses and injuries and arrange for appropriate transfer.

Emergency care may range from the suturing of lacerations to full-scale emergency medical procedures.

Facilities that include personnel and equipment for definitive emergency care should provide for 24-hour service and complete emergency care leading to discharge to the patient’s home or direct admission to the appropriate hospital [10].

The emergency hospital must provisions for emergency treatment for staff, employees, and visitors, as well as for persons who may be unaware of or unable to immediately reach services in other facilities. This is not only for patients with minor illnesses or injuries that may require minimal care but also for persons with severe illness and injuries who must receive immediate emergency care and assistance prior to transport to other facilities[11].

The separate emergency facility provides expeditious emergency care where travel time to appropriate hospital units may be excessive. It may include provisions for temporary observation of patients until release or transfer [10].

4.5. General design considerations

4.5.1. Location:

A hospital and other health facilities shall be so located that it is readily accessible to the community and reasonably free from undue noise, smoke, dust, foul odor, flood, and shall not be located adjacent to railroads, freight yards, children's playgrounds, airports, industrial plants, disposal plants.

The emergency facility shall be conveniently accessible to the population served and shall provide patient transfer to appropriate hospitals. In selecting location, consideration shall be given to factors affecting source and quantity of patient load, including highway systems, industrial plants, and recreational areas.

Though remarkable number of emergency patients will arrive by private cars, consideration should also be given to availability of public transportation.

A building designed for other purpose shall not be converted into a hospital. The location of a hospital shall comply with all local zoning ordinances [10].

4.5.2. Roads:

Paved roads shall be provided within the property for access to all entrances and to loading and unloading docks (for delivery trucks).

The emergency hospitals shall have the emergency access well marked to facilitate entry from the public roads or streets serving the site. Other vehicular or pedestrian traffic should not conflict with access to the emergency station. In addition, access to emergency services shall be located to incur minimal damage from floods and other natural disasters. Paved walkways shall be provided for pedestrian traffic [10].

4.5.3. Environmental design:

4.5.3.1. Site Layout and Orientation:

Siting and orientation are important parts of every project's design as they affect the potential to capture or avoid natural energy.

In general, building on an East/West axis provides a more energy efficient plan [9].

4.5.3.2. Planning:

The planning of rooms should also consider the influence of climate. Patient and habitable rooms should be located on North and South facades with service areas located on the East and West [11].

4.5.3.3. Daylight Control:

Daylight control is generally required on all windows facing North, East and West. In the Northern latitudes sun control is also required on the south. Sun screening devices should be designed to ensure that direct sun does not occur on the working plane [11].

4.5.3.4. Air Movement and Wind Shelter

The direction and velocity of wind and air movement significantly affect the achieved thermal comfort and the overall energy use of a building. Consideration should be given in the design process to providing protection for cold winter and hot summer winds and utilising the cool prevailing breezes in summer [12].

4.5.4. Energy management:

Energy demands are affected by the building envelope or exterior enclosure including configuration, fenestrations, wall materials, colours, insulation, sealing, area of exposure of roof and walls, overhangs and mass. These issues should be considered in the process of selecting materials for the building envelope [9].

4.5.5. Acoustics:

Acoustic issues need to be addressed throughout the design process to ensure best value is achieved. The acoustic requirements are considered under the following major headings:

4.5.5.1. Planning:

Planning is the key to achieving a good working environment within a building. Existing buildings generally have varying background noise levels.

4.5.5.2. Neighbourhood Annoyance:

These regulations set the maximum permissible sound level at the boundary of the site for various times of the day.

4.5.5.3. Background Noise:

In existing buildings it may be possible to measure background noise levels prior to upgrading. To assist in appropriate planning, existing buildings should be acoustically surveyed where possible.

4.5.5.4. Hydraulic Noise:

Plumbing noise can be intrusive at low sound level because of its informational content and ease of propagation via structure-borne paths. For an acceptable acoustic environment it is essential that all plumbing noise sources are considered, both for the adjacent spaces and other floors.

4.5.5.5. Acoustic Isolation:

The acoustic isolation provided between various spaces shall be designed to ensure that the noise level in neighbouring spaces does not exceed the design sound levels'.
In addition to the above requirement, certain rooms require specific acoustic isolation.

4.5.5.6. Room Acoustics

Some spaces require specialist acoustic treatment in terms of Room Acoustic design. These rooms include:

1. Speech Pathology areas
2. Audiological Test Booths
3. Chapels
4. Conference/Seminar rooms
5. Lecture Theatres

The acoustic design issues that shall be separately considered include speech intelligibility, acoustic isolation, reverberation, sound reflection patterns and background noise [10].

4.6. Developing a design strategy

The emergency hospital design strategy should be driven by the patient-focused activities and the spaces needed to accommodate these activities as shown in figure (4.2).
Some of these will be familiar to designers (for example wheelchair turning circles), but a more developed understanding by the team of the tasks and processes will be necessary [9].

Figure (4.2): A hierarchy of space should be driven by patient and staff needs

4.6.1. Activity space:

The functional space may be used for a number of different activities, but design around parallel or sequential activity should allow sufficient area to ensure clinical risk is quantified and minimised.
Engineering requirements such as room air temperatures, ventilation requirements and safe hot water temperatures, as well as surface finishes, building components, equipment and furniture are incorporated in the layout see figure (4.3) [9].

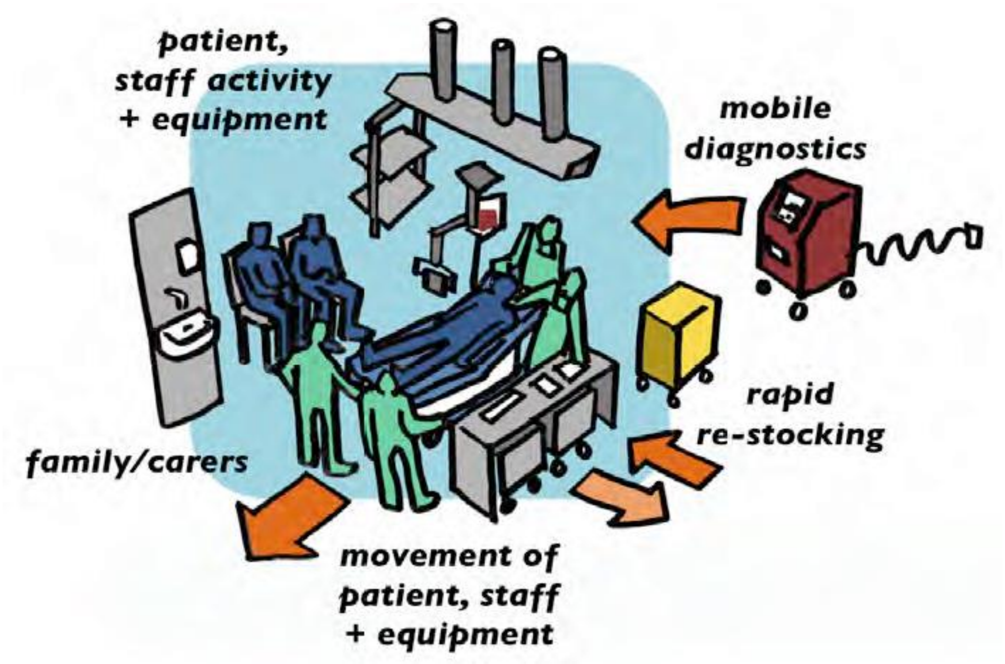

Figure (4.3) sketch present space is developed around activity and equipment needs

4.7. Spatial requirements

Derived from activity and equipment, focused around the patient, the spatial requirements should be considered in terms of free space as well as the equipment needed to perform the above, incorporating ergonomic data and the adjacencies of sequential activities to develop a dynamic task envelope. These will also be dependent on adjacency, proximity and handing requirements, which may be based on acuity. They may change to accommodate changing equipment and patient expectation; therefore the design should incorporate adequate adaptability [10].

4.7.1. Patient Movement:

In emergency hospitals spaces shall be wide enough for free movement of patients, whether they are on beds, stretchers, or wheelchairs and teams attending to patients and their safe access and movement. circulation routes for transferring patients from one area to another shall be available and free at all times.

Corridors for access by patient and equipment shall have a minimum width of 2.44 meters.

Corridors in areas not commonly used for bed, stretcher and equipment transport may be reduced in width to 1.83 meters [12].

4.7.2. Zoning:

The different areas of a hospital shall be grouped according to zones as follows:

4.7.2.1 Outer Zone: areas that are immediately accessible to the public which include

1. Emergency rooms
2. Wheelchair storage
3. Administrative service

They shall be located near the entrance of the hospital.

4.7.2.2 Second Zone: Areas that receive workload from the outer zone include:

1. Laboratory service area
2. Pharmacy
3. Radiology department

They shall be located near the outer zone.

4.7.2.3 Inner Zone: Areas that provide nursing care and management of Patients. They shall be located in private areas but accessible to guests.

4.7.2.4 Deep Zone: Areas that require asepsis to perform the prescribed services:

1. Surgical service
2. Nursery
3. Intensive care area

They shall be segregated from the public areas but accessible to the outer, second and inner zones.

4.7.2.5 Service Zone: Areas that provide support to hospital activities:

1. Dietary service
2. Housekeeping service
3. Maintenance
4. Parking area
5. Mosque
6. Garden

They shall be located in areas away from normal traffic and immediate access.

A separate entrance the different areas of a hospital shall be functionally related with each other.

All emergency hospital service shall be located in the ground floor to ensure to the emergency room shall be quickly provided [4].

4.8. Public and Administrative Areas

4.8.1. Public services

Include:

4.8.1.1. Wheelchairs and stretchers storage

A holding area for wheelchair and stretchers, it's near to the entrance, away from traffic and under staff controls.

4.8.1.2. Reception

A reception and information counter or desk it shall be 5.02 square meters per staff [12].

4.8.1.3. Waiting space(s):

Depend on the hospital patient capacity; the total space should be $0.5m^2$ per patient. Waiting areas shall satisfy the following requirements:

I. Convenient access to wheelchairs and stretchers shall be provided at the emergency entrance.

II. Reception and information function may be combined or separate. These areas shall provide direct visual control of the emergency entrance, and access to the treatment area and the lobby. They shall include a public toilet with hand washing stations, and convenient telephone. Control stations will normally include triage function and shall be indirect communication with medical staff. Emergency entrance control functions shall include observation of arriving vehicles.

III. The emergency waiting area shall include provisions for wheelchairs and be separate from the area provided for scheduled outpatient service.

IV. If so determined by the hospital infection control risk assessment, the diagnostic imaging waiting area may require special consideration to reduce the risk of airborne infection transmission. In these circumstances, public waiting areas shall be designed, ventilated, and maintained with available technologies such as enhanced general ventilation and air disinfection techniques similar to inpatient requirements for airborne infection isolation rooms [12].

Figure (4.4) waiting area

4.8.1.4. Conveniently accessible public toilet(s)

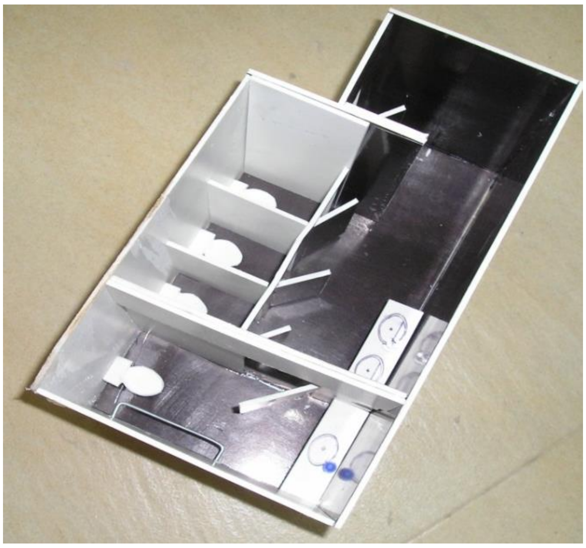

Figure (4.5) public toilet

4.8.1.5. Parking

Not less than one parking space for each staff member on duty at any one time and not less than two spaces for each examination and each treatment room shall be provided. Additional spaces shall be provided for emergency vehicles. Street, public, and shared lot spaces, if included as part of this standard, shall be exclusively for the use of the emergency facility. All required parking spaces shall be convenient to the

emergency entrance. A formal parking/traffic study should be conducted to ensure that adequate parking and traffic flow is provided to accommodate inpatients, outpatients, staff, and visitors. Separate and additional space shall be provided for service delivery vehicles and vehicles utilized for emergency patients [10].
An emergency hospital parking design see figure (4.6).

Figure (4.6) emergency hospital parking

4.8.1.6. Mosque:

The mosque is very important in hospital, locate in the service zone, it must provide two section (male and female).
The inside hospital's mosque design was shown in figure (4.7).

Figure (4.7) hospital mosque

4.8.1.7. Garden

Well-designed hospital gardens not only provide restorative and pleasant nature views, but also can reduce stress and improve clinical outcomes through other mechanisms such as increasing access to social support, and providing opportunities for positive escape from stressful clinical settings as figure (4.8).

The hospital garden area must calculate as 10 square meters per bed.

Figure (4.8) hospital garden

4.8.1.8. Dietary Facilities:

Food service facilities and equipment shall conform to these standards and with the standards of the national Sanitation foundation and other appropriate codes and shall provide food service for staff, visitors, inpatients, and outpatients as may be appropriate [12].

Consideration may also be required for cafeterias for staff, see figure (4.9), ambulatory patients, and visitors as well as providing for nourishments and snacks between scheduled meal services.

Patient food preparation areas shall be located in an area adjacent to delivery, interior transportation, storage, etc.

Finishes in the dietary facility shall be selected to ensure it is able to clean and the maintenance of sanitary conditions.

- Patient food Preparation Area	4.65 square meters
- Serving and Food Assembly Area	4.65 square meters
- Dining Area	1.40 square meters per person [10]

Figure (4.9) dietary area

4.8.1.9. Housekeeping room:

One housekeeping room shall be provided for the unit. It shall be directly accessible from the unit and be dedicated for the exclusive use of the neonatal critical care unit. It shall contain a service sink or floor receptor and provisions for storage of supplies and housekeeping equipment.

4.8.1.10 Soiled holding:

Provisions shall be made for separate collection, storage, and disposal of soiled materials and medical west.

4.8.1.11. Staff lounge and toilet facilities:

Separate lounges for male and female staff shall be provided. Lounge(s) shall be designed to minimize the need to leave the suite and to provide convenient access to the recovery room. A minimum size is 9 square meters

Some part of hospital shall contain at least two toilets for male and female, for staff uses and patient in addition to the public toilet for visitor.

The minimum space for each toilet 1.67 square meters [12].

4.8.1.12. Hand washing station:

General hand washing stations used by medical and nursing staff and all lavatories used by patients and food handlers shall be trimmed with valves that can be operated without hands. (Single lever or wrist

blade devices may be used.) Blade handles used for this purpose shall not exceed 4-1/2 inches (114.3 millimetres) in length.
Handles on clinical sinks shall be at least 6 inches (152.4 millimetres) long.
Freestanding scrub sinks and lavatories used for scrubbing in procedure rooms shall be trimmed with foot, knee, or ultrasonic controls (no single lever wrist blades) see figure (4.10).
Mirrors shall not be installed at hand washing stations in food preparation areas, nurseries, clean and sterile supply areas, scrub sinks, or other areas where asepsis control would be lessened by hair combing [10].

Figure (4.10) hand washing station

4.8.2. Administrative area

The administrative are include:

4.8.2.1. General or individual office(s): for business transactions, records, administrative, and professional staffs shall be provided.

4.8.2.2. Clerical space or room(s): for typing, clerical work, and filing, separated from public areas for confidentiality, shall be provided.

4.8.2.3. Multipurpose room(s): equipped for visual aids shall be provided for conferences, meetings, and health education purposes.

4.8.2.4. Special storage: for staff personal effects with locking drawers or cabinets (may be individual desks or cabinets) shall be provided. Such storage shall be near individual work stations and staff controlled.

4.8.2.5. General storage facilities: for supplies and equipment shall be provided as needed for continuing operation.

4.8.2.6. Employee Facilities: Staff locker rooms and toilets shall be provided. In addition, facilities for on-call medical staff shall be provided [12].

4.9. Clinical Facilities

4.9.1. Main emergency facilities

As needed, the following elements shall be provided for clinical services to satisfy the functional program:

4.9.1.1 General-purpose examination room(s)

For medical, obstetrical, and similar examinations, rooms shall have a minimum floor area of 80 square feet (7.43 square meters), excluding vestibules, toilets, and closets. Room arrangement should permit at least 2 feet 8 inches (812.8 millimetres) clearance at each side and at the foot of the examination table. A hand washing station and a counter or shelf space for writing shall be provided, see figure (4.11).

Figure (4.11) general examination room

4.9.1.2 Child examination room:

Room with special paediatric equipment shall have minimum area (5.5 square meters)

4.9.1.3. Special-purpose examination rooms:

Rooms for special clinics such as eye, ear, nose, and throat examinations, if provided, shall be designed and outfitted to accommodate procedures and equipment used. A hand washing station and a counter or shelf space for writing shall be provided.

4.9.1.4. Treatment room(s):

Rooms for minor surgical and cast procedures shall have a minimum floor area of 120 square feet (11.15 square meters), excluding vestibule, toilet, and closets. The minimum room dimension shall be 10 feet (3.05 meters). A hand washing station and a counter or shelf for writing shall be provided [12].

4.9.1.5. Isolation room(s):

Observation rooms for the isolation of suspect or disturbed patients shall have a minimum floor area of 80 square feet (7.43 square meters) and shall be convenient to a nurse or control station. This is to permit close observation of patients and to minimize possibilities of patients' hiding, escape, injury, or suicide.

- An examination room may be modified to accommodate this function.
- A toilet room with lavatory should be immediately accessible [11].

4.9.1.6. Clean storage:

A separate room or closet for storing clean and sterile supplies shall be provided. This storage shall be in addition to that of cabinets and shelves.

4.9.1.7. Infection isolation room(s):

The need for and number of required airborne infection isolation rooms shall be determined by an infection control risk assessment.

4.9.2. Sterilizing facilities:

A system for sterilizing equipment and supplies shall be provided. Sterilizing procedures may be done on- or off-site, or disposables may be used to satisfy functional needs. Minimum space for Sterile Instrument, Supply and Storage area not less than 4.65 square meters. Sup sterile area should be also not less than 4.65 square meters [12]. See figure (4.12).

Figure (4.12) sterilizing facility

4.9.3. Trauma/cardiac room

Trauma/cardiac rooms for emergency procedures, including emergency surgery, shall have at least 250 square feet (23.23 square meters) of clear floor space. Each room shall have cabinets and emergency supply shelves, X-ray film illuminators, examination lights, and counter space for writing. Additional space with cubicle curtains for privacy may be provided to accommodate more than one patient at a time in the trauma room. Provisions shall be made for monitoring the patient. There shall be storage provided for immediate access to attire used for universal precautions. Doorways leading from the ambulance entrance to the cardiac trauma room shall be a minimum of 5 feet (1.52 meters) wide to simultaneously accommodate stretchers, equipment, and personnel as shown in figure (4.13).

In renovation projects, every effort shall be made to have existing cardiac/trauma rooms meet the above minimum standards. If it is not possible to meet the above square-foot standards, the authorities having jurisdiction may grant approval to deviate from this requirement. In such cases, these rooms shall be no less than a clear area of 240 square feet (21 square meters), and doorways leading from the ambulance entrance to the room may be 4 feet (1.22 meters) wide.

Convenient access to radiology and laboratory services also provides.

a. A cardiopulmonary resuscitation (CPR) emergency cart, away from traffic but immediately available to all areas including entrance and receiving areas.

b. At least two examination rooms and one trauma/cardiac room (treatment room may also be utilized for examination) [12].

Figure (4.13) trauma/cardiac room

4.9.4. Nurse's station

Regardless of which organizational type, there are five key principles to consider when designing a nurse station or series of stations:

1. Allow for Control and Flexibility:
2. Understand Work Processes
3. Maximize Adjacencies
4. Support Collaboration
5. Reduce Cognitive Load.

4.9.4.1. Nurse station categories:

According to the function of the nurse station two common approaches can be defined:

1. Centralized.
2. Decentralized nursing stations.

According to the shape: (see figure (4.14))

1. Diamond
2. Octagon
3. Circle
4. Half circle [17].

Figure (4.14) nurse's station shapes: (A) Diamond shape, (B) Octagon shape, (C) Half circle and (D) Circle shape

4.9.4.2. Key Design Recommendations

These recommendations include:

i. Locate a clearly marked entry that opens directly onto a reception area (see figure (4.15) zoon-1 and 2).
ii. Position the reception area to provide first contact with family and to assist visitors (this preserves nurses' personal space and minimizes interruptions to their work) (see figure (4.15) zoon-2).
iii. Use one central nursing station (see figure (4.15) zoon-6) with two to four small decentralized work stations (see figure (4.15) zoon-3).
iv. Place the most critical patients closest to a nursing station to maximize view and accessibility (see figure (4.15) zoon- 3).
v. Locate linens in patient rooms and store medical and office supplies inside the central nursing station (see figure (4.15) zoon-6).
vi. Locate enclosed formal meeting space within the centralized nursing station area (see figure (4.15) zoon-6).

vii. Place a separate room for family members and a staff room at the end of hallways, away from the central station (see figure (24.15) zoon-4 and 5).

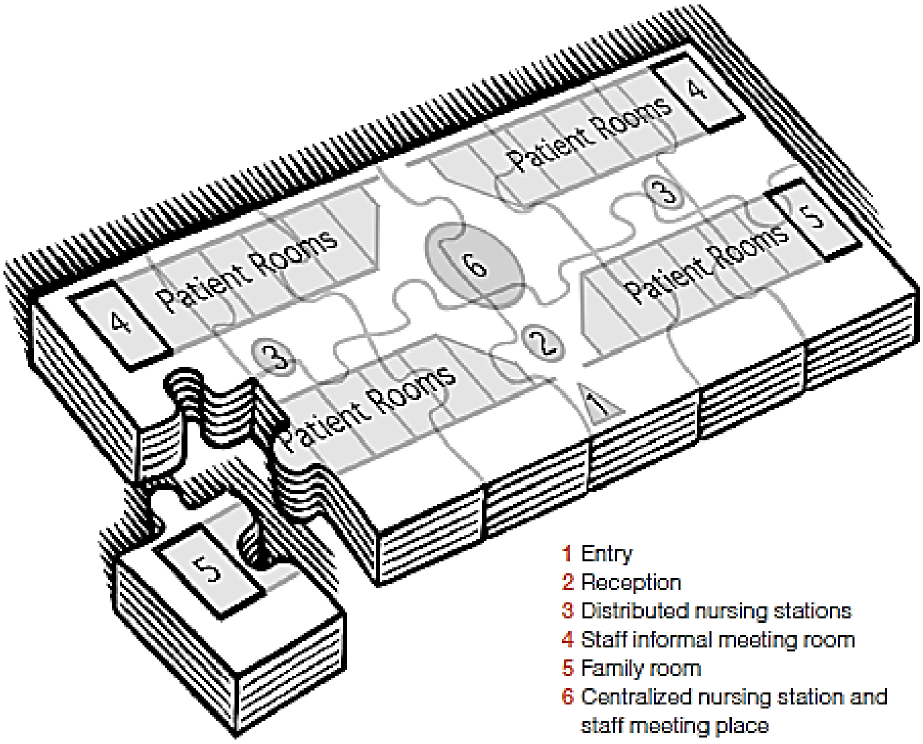

Figure (4.15) location of centralized and distributed nurse station

A nurse's work and control station shall accommodate charting, files, and staff consultation activities. It shall be located to permit visual control of clinical area and its access. Communication links with the examination/treatment area, trauma/cardiac room, reception control, laboratory, radiology, and on-call staff shall be provided, a work counter, communication system, space for supplies and provisions for charting shall be provided [9].

4.9.5. Imaging Department

Basic diagnostic procedures shall be provided, including the following:

4.9.5.1. Fluoroscopy:

Fluoroscopy rooms should be a minimum of 250 square feet (23.23 square meters).

Figure (4.16) fluoroscopy room

4.9.5.2. Radiography:

Radiography rooms should be a minimum of 180 square feet (7.43 square meters).

Each X-ray room shall include a shielded control alcove. This area shall be provided with a view window designed to provide full view of the examination table and the patient at all times, including full view of the patient when the table is in the tilt position or the chest X-ray is being utilized, see figure (4.17).

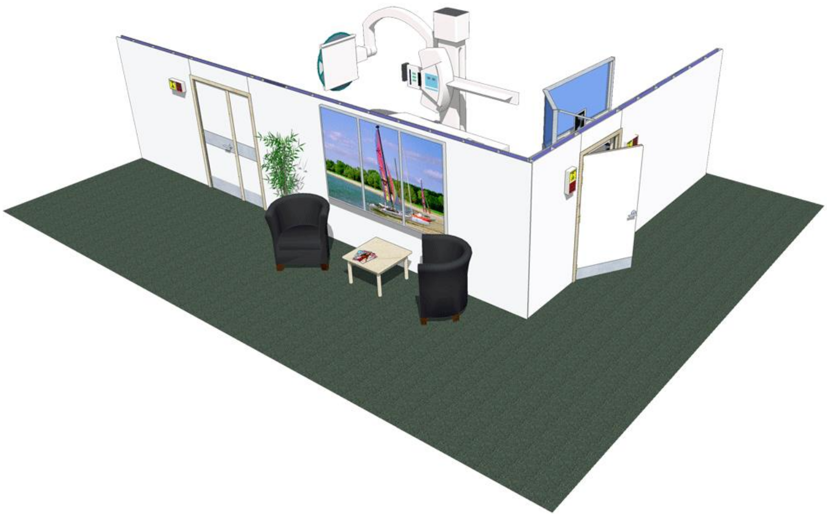

Figure (4.17) x-ray examination room

4.9.5.3. Computerized tomography scanning (CT):

CT scan rooms shall be as required to accommodate the equipment.
A control room shall be provided that is designed to accommodate the computer and other controls for the equipment. A view window shall be provided to permit full view of the patient. The angle between the control and equipment centroid shall permit the control operator to see the patient's head see figure (4.18).
The control room shall be located to allow convenient film processing.
A patient toilet shall be provided. It shall be convenient to the procedure room and, if directly accessible to the scan room, arranged so that a patient can leave the toilet without having to re-enter the scan room.

Figure (4.18) CT scan room

4.9.5.4. Ultrasound:

Space shall be provided as necessary to accommodate the functional program. A patient toilet, accessible from the procedure room, shall be provided.

Figure (4.19) ultrasound room

4.9.5.5. Magnetic resonance imaging (MRI)

Space shall be provided as necessary to accommodate the functional program. The MRI room shall be permitted to range from 325 square feet (30.19 square meters) to 620 square feet (57.6 square meters) depending on the vendor and magnet strength.

Figure (4.20) MRI room

Cryogen venting is required, see figure (4.21); MRI systems use cryogens (usually helium) to cool the magnet in the MRI scanner. There are specific cryogen requirements of the MRI, as well for the room build-out needed to insure that the scanner is kept cool and working both properly and safely.

Cryogen storage may be required in areas where service to replenish supplies is not readily available. When provided, space should be a minimum of 50 square feet (4.65 square meters) to accommodate two large dewars of cryogen.

A control room shall be provided with full view of the MRI, also computer room, Cryogen storage, Power conditioning, Magnetic shielding and Patient hold area shall be provided [16].

Figure (4.21) cryogen venting

Figure (4.22) imaging suite

4.9.5.6. Shielding in imaging department

4.9.5.6.1. X-ray rooms:

The shielding of x-ray rooms include wall, doors and windows, the details of x-ray rooms shielding as following:

4.9.5.6.1.1 Wall:

For general X‑ray rooms, the lead equivalence required is typically of the order of 2 mm at 150 kV although a lead equivalence of 3-4 mm or more may be required for multi-slice CT installations.

As an alternative to using concrete, wall shielding may be provided using panels of lead plasterboard or lead plywood. The internal walls of many modern buildings are composed of plasterboard attached to both sides of metal or wooden framing. Lead plywood or plasterboard may be used on one side of the internal framing to achieve the required shielding. Ideally it should be used on the side which will require the least perforation. Lead plasterboard is less robust than lead plywood during handling; however it leaves a smooth finish for decorating.

The shielding must not be compromised at the joints between panels and where nails, screws and other fixings are used. Lead lined battens should be used at the joints. These are typically 50 mm wide and provide a secure base for fixing the panels [13].

Their lead thickness should be the same as that in the panels and they should have a sufficient overlap with each panel to provide protection at the joint and for the nails and screws.

Steel nails and screws however generally attenuate radiation equally or more effectively than the lead displaced by the nails, therefore steel nails or screws used to secure lead barriers may not need to be covered with lead discs or supplementary lead. However, where the edges of two lead sheets meet, continuity must be ensured at the joints with lead battens

Walls are generally shielded to full height from the floor to the underside of the ceiling slab above, unless the protection in the ceiling extends well beyond the X‑ray room. This is to protect not only the room directly above but also the adjoining rooms above, but, if the hospital consists of only ground floor so, the height of lead must be only 2m from the floor.

If the X‑ray room is adjacent to a dark room or a storage facility for CR plates, shielding to full height is required to protect films/CR plates located on high-level shelving.

4.9.5.6.1.2. Floor:

Imaging facilities are frequently located on the ground floor of hospitals. Floor shielding is not necessary if there are no occupied basements or under floor service corridors.

4.9.5.6.1.3. Doors:

There may be several doors leading to an X‑ray room including the patient door, the staff door, and doors to changing cubicles or possibly to a patient toilet. The room should be designed so that the uninterrupted X‑ray beam will not normally be directed towards doors, windows, or the operator’s console. Even with this provision the door and doorframe must be shielded against scatter.

The shielding must be uninterrupted between double doors, between the door and frame, and between the doorframe and the adjoining wall. Generally the minimum overlap is 1.5 cm. In the case of a concrete or brick wall, the shielding should overlap the doorframe and wall by a distance at least equivalent to the thickness of the concrete or brick in the wall.

Doors should be of solid construction with the lead bonded on both sides by wood or a suitable alternate protective material

The shielding must run the entire length and width of the door down to a few mm from the floor, and continue on the underside. Doors may include lead glass windows.

Access through doors must be controlled by the use of appropriate lights and signs, unless the entrance is locked during exposures (as may be the case with doors leading to/from changing cubicles or toilets).

Warning lights should preferably be located beside the door at eye level.

4.9.5.6.1.4. Windows:

Unshielded windows at a height of greater than 2 m from the outside ground were previously considered to be acceptable.

For general rooms, the lead equivalence of the window required may be 2 mm at 150 kV depending on the workload, the occupancy outside, and the distance to the nearest occupied area, although windows of 3‑4 mm lead equivalence at 150 kV or more may be required for multi-slice CT and angiographic installations.

If windows are required in X‑ray rooms, they may be shielded by lead glass or lead acrylic. These should be provided in the form of double-glazing, with plate glass on the outside as lead glass and lead acrylic may be easily damaged and lead glass must be kept dry. Window frames must also be shielded with sufficient overlap provided between the window and window frame and between the window frame and wall.

Windows should be marked with the lead equivalent thickness. Alternatively, windows may be shielded by lead blinds or shutters. A range of lead blinds is available including electronically operated vertical blinds. The blinds should also be marked with the lead equivalent thickness. The primary beam should not be routinely directed towards a window [13].

4.9.5.6.2. MRI Shielding:

MRI systems have their own requirements for shielding, space, acoustics, vibration, power, air conditioning, and so forth. MRI shielding is also different than X-ray shielding, requires radio frequency shielding (RF) nearly 100% of the time with the exception being some small research MR systems. Following are general RF shielding sense frequencies:

9.8 MHz	0.23T
12.7 MHz	0.3 T
15.0 MHz	0.35T
21.3 MHz	0.5 T
42.6 MHz	1.0 T
63.9 MHz	1.5 T
200.2 MHz	4.7 T
300.0 MHz	7.0 T
400.0 MHz	9.4 T

The RF-shield must encircle the entire room - walls, floor, and ceiling. Such a conductive box used to shield out stray electromagnetic interference is also known as a Faraday cage, see figure (4.23, A).

Virtually any type of metal can be used, including aluminium and galvanized steel. However, the most common RF-enclosure consists of wood panels wrapped with copper. At the range of frequencies used for MRI the skin conductive depth for copper is very small (on the order of 0.1 mm), meaning that only a thin layer of metallic shielding is required.

The floor is generally made of monolithic copper covered over with a solid flooring material. The interior walls are typically finished with drywall. The ceiling is suspended from the RF shield to allow space for recessed lighting and mechanicals. The door must not allow any RF leakage, being sealed by a set of electrical contact strips or a continuous metallic pneumatic tube. Windows are laminated with blackened copper mesh between two pieces of glass that connects peripherally with the RF enclosure walls [16].

An RF band-stop filter is a passive electronic element consisting of inductive and capacitive components placed in series with the electrical line that penetrates the enclosure. This filter allows passage of all frequencies except those in a narrow range surrounding the Larmor frequency for pipes, ducts, fiber optic cables, and tubing a different type of filter is needed, called a waveguide. The type of waveguide used in MR facilities is usually a circular type (see figure (4.23, B)) with a cut-off well below the Larmor frequency. In the range of frequencies used in MRI (10-300 MHz) a cylinder with a length: width ratio of 4:1 or greater will be effective at blocking radiofrequencies in the desired range. For those interested in the underlying theory for how this works, an advanced reference is provided [18].

Figure (4.23) MRI shielding, (A) Copper RF-shielding in a magnet room, (B) Penetration panel with protruding waveguide though which hoses and tubes may be passed.

4.9.6. Laboratory

Facilities shall be provided within the outpatient department, or through an effective contract arrangement with a nearby hospital or laboratory service, for hematology, clinical chemistry, urinalysis, cytology, pathology, and bacteriology. The Examination and Treatment Area with Lavatory/Sink should be a minimum of (7.43 square meters) per bed .If these services are provided on contract, the following laboratory facilities shall also be provided the outpatient facility:

- Laboratory work counter(s), with sink, vacuum, gas, and electric services.
- Storage cabinet(s) or closet(s).
- Specimen (blood, urine, and feces) collection facility shall be provided. Blood collection area shall have work counter, space for patient seating, and hand washing stations. Urine and feces collection room shall be equipped with water closet and lavatory see figure (4.24).

Figure (4.24) laboratory site

In addition, immediate access to blood for transfusions and provisions for cross-match capabilities shall be provided.

The laboratory must be completely separated from outside areas (i.e., must be bound by four walls) [14].

4.9.7. Pharmacy

The size and type of services to be provided in the pharmacy will depend upon the type of drug distribution system used, number of patients to be served, and extent of shared or purchased services. This shall be described in the functional program. The pharmacy room or suite shall be located for convenient access, staff control, and security, see figure (4.25).

The required pharmacy space should be 15.00 square meters. Secure storage for narcotics and controlled drugs [11].

Figure (4.25) 3D pharmacy design

4.9.8. Surgical department

The clinical practice setting shall be designed to facilitate movement of patients and personnel into and out of defined areas within the surgical suite, see figure (4.26). Signs shall clearly indicate the surgical attire required.

Figure (4.26) surgical unit rooms

4.9.8.1. General operating room(s)

In new construction, each room shall have a minimum clear area of 400 square feet (37.16 square meters) exclusive of fixed or wall-mounted cabinets and built-in shelves, with a minimum of 20 feet (6.10 meters) clear dimension between fixed cabinets and built-in shelves; and a system for emergency communication with the surgical suite control station.

Where renovation work is undertaken, every effort shall be made to meet the above minimum standards. If it is not possible to meet the above square-foot standards, the authorities having jurisdiction may grant approval to deviate from this requirement. In such cases, each room shall have a minimum clear area of 360 square feet (33.45 square meters), exclusive of fixed or wall-mounted cabinets and built-in shelves, with a minimum of 18 feet (5.49 meters) clear dimension between fixed cabinets and built-in shelves.

4.9.8.2. Post-anaesthetic care units (PACUs)

Each PACU shall contain a medication station; hand washing stations; nurse station with charting facilities; clinical sink; provisions for bedpan cleaning; and storage space for stretchers, supplies, and equipment.

Additionally, the design shall provide a minimum of 80 square feet (7.43 square meters) for each patient bed with a space for additional equipment described in the functional program, and for clearance of at least 5 feet (1.52 meters) between patient beds and 4 feet (1.22 meters) between patient bedsides and adjacent walls. Provisions shall be made for the isolation of infectious patients. Provisions for patient privacy such as cubicle curtains shall be made.

In new construction, at least one door to the recovery room shall access directly from the surgical suite without crossing public hospital corridors.

An airborne infection isolation room is not required in a PACU. Provisions for the recovery of a potentially infectious patient with an airborne infection shall be determined by the Infection Control Risk assessment.

A staff toilet shall be located within the working area to maintain staff availability to patients. Hand washing stations with hands-free operable controls shall be available with at least one for every four beds uniformly distributed to provide equal access from each patient bed [12].

4.9.8.3. Service Areas:

A control station located to permit visual observation of all traffic into the suite.

4.9.8.4. A supervisor's office or station

The number of offices, stations, and teaching areas in the surgical suite shall depend upon the functional program.

4.9.8.5. A sub-sterile areas:

Acts as a service area between two or more operating or procedure rooms and shall be equipped with a flash sterilizer, warming cabinet, sterile supply storage area, and hand washing station with hands-free controls. A sterilizing facility with high-speed sterilizer(s) or other sterilizing equipment for immediate or emergency use must be grouped to several operating rooms for convenient, efficient use. A work space and hand washing station may be included. Other facilities for processing and sterilizing reusable instruments, etc., may be located in another hospital department such as central services [11].

4.9.8.6. Staff clothing change areas:

Appropriate areas shall be provided for male and female personnel (orderlies, technicians, nurses, and doctors) working within the surgical suite. The areas shall contain lockers, showers, toilets, lavatories equipped for hand washing, and space for donning surgical attire.

These areas shall be arranged to encourage a one-way traffic pattern so that personnel entering from outside the surgical suite can change and move directly into the surgical suite.

4.9.8.7 Change areas for outpatients and same-day admissions:

If the functional program defines outpatient surgery as part of the surgical suite, a separate area shall be provided where outpatients may change from street clothing into hospital gowns and be prepared for surgery. This would include a waiting room, locker(s), toilet(s), and clothing change or gowning area. Changing may also be accommodated in a private holding room or cubicle [12].

4.9.9 Intensive Care Unit (I.C.U.):

Intensive care units require special space and equipment considerations for safe and effective patient care, staff functions, and family participation. Families and visitors to critical care units often wait for long periods of time, including overnight stays, under highly stressful situations. They tend to congregate at unit entries to be readily accessible to staff interaction. Design shall address such issues as privacy, atmosphere, and aesthetics for all involved in the care and comfort of patients in intensive care units see figure (4.27).

Figure (4.27) ICU layout

The location shall offer convenient access from the emergency, respiratory therapy, laboratory, radiology, surgery, and other essential departments and services as defined by the functional program. It shall be located so that the medical emergency resuscitation teams may be able to respond promptly to emergency calls within minimum travel time. The location shall be arranged to eliminate the need for through traffic.

In new construction, each patient space (whether separate rooms, cubicles, or multiple bed space) shall have a minimum of 200 square feet (18.58 square meters) of clear floor area with a minimum headwall width of 13 feet (3.96 meters) per bed, exclusive of anterooms, vestibules, toilet rooms, closets, lockers, wardrobes, and/or alcoves.

Each patient bed area shall have space at each bedside for visitors, and provisions for visual privacy from casual observation by other patients and visitors. For both adult and paediatric units, there shall be a minimum of 8 feet (2.44 meters) between beds.

Each patient bed shall have visual access, other than skylights, to the outside environment with not less than one outside window in each patient bed area.

In renovation projects, clerestory windows with windowsills above the heights of adjacent ceilings may be used, provided they afford patients a

view of the exterior and are equipped with appropriate forms of glare and sun control.
Distance from the patient bed to the outside window shall not exceed 50 feet (15.24 meters).
Nurse station: This area shall have space for counters and storage.
Each unit shall contain equipment for continuous monitoring, with visual displays for each patient at the bedside and at the nurse station. Monitors shall be located to permit easy viewing.
The electrical, medical gas, heating, and air conditioning shall support the needs of the patients and critical care team members under normal and emergency situations [12].

4.9.10. Biomedical Engineering (BME) Service and equipment Areas

Sufficient space shall be included in all mechanical and electrical equipment rooms for proper maintenance of equipment.
The minimum area of BME department about 80 square meters.
Provisions shall also be made for removal and replacement of equipment.
Engineer’s office with file space and provisions for protected storage of facility drawings, records, manuals.
General maintenance shop(s) for repair and maintenance.
Separate area or room specifically for storage, cleaning, testing, and repairing, of electronic and other medical equipment. The amount of space and type of utilities will vary with the type of equipment involved and types of outside contracts used see figure (4.28).
Yard equipment and supply storage areas shall be located so that equipment may be moved directly to the exterior without interference with other work.
The buildings and equipment shall be kept in a state of good repair. Proper maintenance shall be provided to prevent untimely breakdown of buildings and equipment.

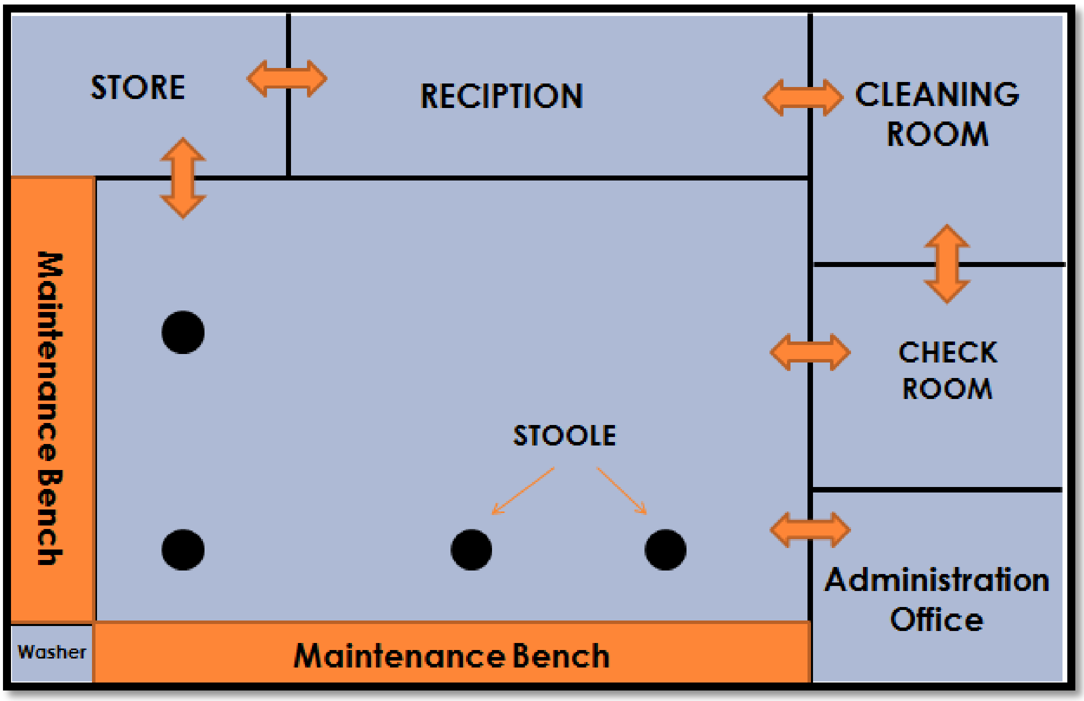

Figure (4.28) BME workshop

4.9.11. Central gas Station:

All medical central stations can be accommodated to special made containerized cabinet for outdoor installations.

Every part of the station is fitted inside the container including the medical gases and electrical connections.

The medical gases used in a hospital are life-supporting element that gives direct influence in maintaining the life of a patient. Therefore, at the sections where the medical gases are used, the medical gas must be clean, highly pure and supplied under stable pressure.

Our medical gas system has cleared those regulations and standards as well as passing our strict company standard. The system has thoroughgoing color coordination according to the kind of gas, see figure (4.29), an audio-visual monitoring system capable of checking the situation, and a device to prevent cross connection at medical gas outlet based on the concept, "more safely" and "more securely" [12].

Figutre (4.29) color pipes

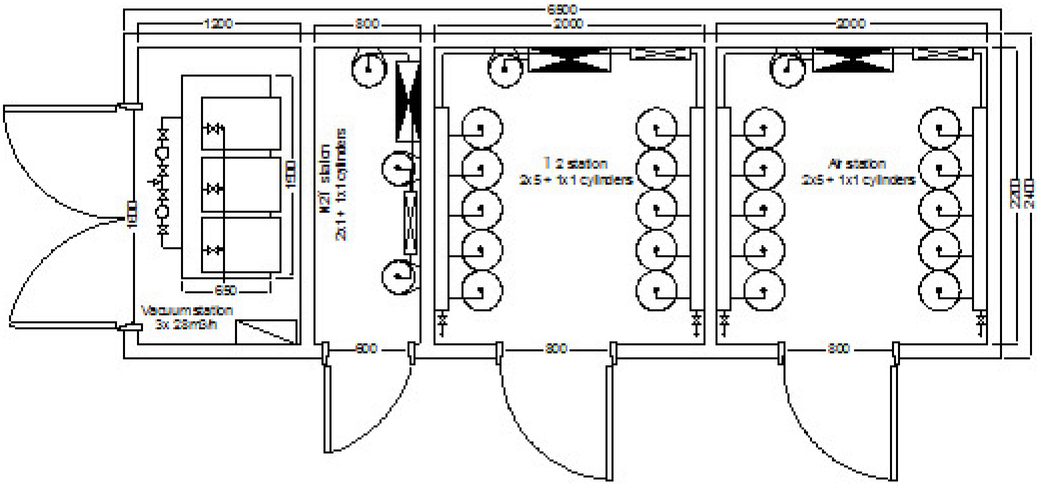

Figure (4.30) cabinet design

4.10. General Standards Details and Finishes

Details and finishes in new construction projects, including additions and alterations, shall comply with the following:

4.10.1. General standard details:

4.10.1.1. Water Supply:

A hospital and other health facilities shall use an approved public water supply system whenever available. The water supply shall be potable, safe for drinking and adequate, and shall be brought into the building free of cross connections.

4.10.1.2. Waste Processing Services:

Storage and disposal Facilities shall be provided for sanitary storage and treatment or disposal of waste using techniques acceptable to the appropriate health and environmental authorities.

The functional program shall stipulate the categories and volumes of waste for disposal and shall stipulate the methods of disposal for each.

Medical waste shall be disposed of either by incineration or other approved technologies. Incinerators or other major disposal equipment may be shared by two or more institutions [5].

4.10.1.3. Fire Safety:

It is a requirement of the licence issued by the Commissioner for hospitals to operate that all of the facilities that go to make up the hospital be adequately maintained.

This also includes the fire prevention and protection aspects of the building fabric.

All fire safety prevention and protection facilities shall be maintained in accordance with the relevant Australian Standards, where such exist. In their absence, manufacturers' recommendations shall set the standard.

It is also important to note that no area within a hospital shall have a function change without a re-assessment of the modified fire risk and fire safety provisions by the Commissioner [9].

Figure (4.31): fire safety

4.10.1.4. Sanitation:

Utilities for the maintenance of sanitary system, including approved water supply and sewerage system, shall be provided through the buildings and premises to ensure a clean and healthy environment.

4.10.1.5. Segregation:

Wards shall observe segregation of sexes. Separate toilet shall be maintained for patients and personnel, male and female, with a ratio of one toilet for every eight patients or personnel [12].

Figure (4.32) segregation sign

- Rooms containing heat-producing equipment (such as boiler rooms, heater rooms, and laundries) shall be insulated and ventilated to prevent the floors of occupied areas overhead and the adjacent walls from exceeding a temperature of 10°F (6°C) above the ambient room temperature of such occupied areas [10].

4.10.1.6. Doors:

Doors to all rooms containing bathtubs, sitz baths, showers, and toilets for resident use shall be hinged, sliding, or folding.

The minimum dimensions of clear door openings to inpatient bedrooms in new areas shall be 1200mm wide and 2030mm high, to ensure clearance for the movement of beds.

In general, clear door openings to rooms which may be accessed by stretchers (including wheeled bed stretchers), wheelchairs or handicapped persons (including employees), shall be a minimum of 900mm.

(1000mm recommended for some situations, e.g. hoists, shower trolleys etc.).

Clear door openings in corridors shall suit the requirements of traffic and equipment movement but shall not be less than 1200mm.

While these standards are intended to facilitate access by personnel and mobile equipment, consideration must be given to the size of furniture and special equipment that is to be delivered via these access ways.
All doors between corridors and rooms or spaces subject to constant patient or staff occupancy shall be of the single or double leaf swing type.
Door closers should be considered for doors that should remain closed; e.g. toilet doors. External doors- doors into operating rooms and the operating suite generally, corridor doors etc. Note that closers on doors to disabled toilets can cause access problems. It is recommended that they not be fitted.
Beam activated automatic sliding or swing doors are considered highly desirable in high traffic areas such as main entries and delivery points. They may also be used successfully in areas where "hands-off" access is necessary, e.g. entries to operating suites. Where installed, they are to satisfy the requirements of emergency egress and to close at a rate which provides sufficient time for disabled and frail patients and visitors to enter/exit. Automatic doors are not mandatory [5].

4.10.1.7. Windows:

All rooms occupied by patients or staff on a regular basis shall have glazed windows or doors to achieve external views and/or make use of direct or borrowed natural light, where practical.
All patient bedrooms shall have external windows overlooking external areas. An external area is defined as the perimeter space around a building as well as naturally ventilated and lit atriums and courtyards.
Each external window and/or external glazed door panel area shall not be less than 10% of the floor area of the room concerned. An opening component equal to not less than 5% of the floor area of that same room is considered highly desirable. These requirements together will ensure natural light and ventilation in the event of an electrical or air handling system failure.
On the other hand, some rooms must not contain windows such as operation room, isolation rooms, and sterile processing rooms.

4.10.2. Finishes:

Finishes in new and remodelled areas shall comply with the following:

4.10.2. 1. Walls:

Other than special treatments included as feature face work in public or staff relaxation areas, wall finishes shall be scrubbable, and in the immediate vicinity of plumbing fixtures, shall be smooth and water-resistant [5].

In operating rooms, isolation rooms, and sterile processing rooms, wall finishes shall be free of fissures, open joints, or crevices that may retain or permit passage of dirt particles [12].

4.10.2.2. Ceilings:

All exposed ceilings and ceiling structures in areas occupied by patients or staff, and in food preparation or food storage areas, shall be finished so as to be readily cleanable with equipment routinely used in daily housekeeping activities. In food preparation and other areas where dust fallout would present a potential problem, there shall be a finished ceiling that covers all conduits, piping, duct work and open construction systems. Ceilings in operating room, isolation rooms, nurseries, and sterile processing rooms shall be monolithic from wall to wall without fissures, open joints, or crevices that may retain or permit passage of dirt particles. Light fittings shall also be recessed and flush fitting and sealed to prevent dust ingress.

Acoustic and/or lay-in ceilings shall not be used where particulate matter may interfere with asepsis control [5].

Ceilings in radiographic, operating rooms, and other rooms containing ceiling-mounted equipment or ceiling-mounted surgical light fixtures shall be of sufficient height to accommodate the equipment or fixtures and their normal movement.

Ceilings in corridors, storage rooms, and toilet rooms shall be not less than 7 feet 8 inches (2.34 meters) in height. Ceiling heights in small, normally unoccupied spaces may be reduced.

Seclusion treatment rooms shall have a minimum ceiling height of 9 feet (2.74 meters) [12].

4.10.2.3. Floor:

Floor materials shall be easily cleanable and appropriately wear-resistant for the location. Floors in areas used for food preparation or food assembly shall be water-resistant. Floor surfaces, including tile joints, shall be resistant to food acids. In all areas subject to frequent wet-cleaning methods, floor materials shall not be physically affected by germicidal cleaning solutions.

Floors subject to traffic while wet (such as shower and bath areas, kitchens, and similar work areas) shall have a nonslip surface.

In new construction or major renovation work, the floors and wall bases of all operating rooms and any delivery rooms used for cesarean sections shall be monolithic and joint free. The floors and wall bases of kitchens, soiled workrooms, and other areas subject to frequent wet cleaning shall also be homogenous, but may have tightly sealed joints.

The selection of floor finishes is very important. It has direct impact on safety (patients, staff and visitors) and has potential legal implications if not correctly addressed

Floor finishes also have a direct impact on the whole of life costs of any building where cleaning and maintenance is concerned.

This is especially true in a hospital. Low capital cost may result in high whole of life costs [5].

4.11. Electrical Standards

4.11.1. Fire Alarm:

All health care occupancies shall be provided with a fire alarm system.

4.11.2. Lighting:

Approaches to buildings and parking lots, and all occupied spaces within buildings shall have fixtures that can be illuminated as necessary.

Patient rooms shall have general lighting and night lighting. A reading light shall be provided for each patient. Reading light controls shall be accessible to the patient(s) without the patient having to get out of bed. Incandescent and halogen light sources that produce heat shall be avoided to prevent burns to the patient and/or bed linen. The light source should be covered by a diffuser or lens.

Operating and delivery rooms shall have general lighting in addition to special lighting units provided at surgical and obstetrical tables. General lighting and special lighting shall be on separate circuits.
Nursing unit corridors shall have general illumination with provisions for reducing light levels at night.
Consideration should be given to controlling intensity and/or wavelength to prevent harm to the patient's eyes (i.e., retina damage to premature infants and cataracts due to ultraviolet light).
A portable or fixed examination light shall be provided for examination, treatment, and trauma rooms [12].

4.11.3. Nurses Calling System:

In patient areas, each patient room shall be served by at least one calling station for two-way voice communication. Each bed shall be provided with a call device. Two call devices serving adjacent beds may be served by one calling station.

4.11.4. Telecommunications and Information Systems:

Locations for terminating telecommunications and information system devices shall be provided.
A room shall be provided for central equipment locations.
Special air conditioning and voltage regulation shall be provided when recommended by the manufacturer.
All patient care-related telecommunications and information systems shall be powered from the essential electrical system [11].

4.12. Medical Equipment Preparation:

Medical equipment, both fixed and mobile, shall be provided in sufficient quantity and quality to satisfy the requirements of the statement of function and to meet minimum occupational health, safety and welfare regulations.
All medical equipment is to be maintained in a clean, safe and serviceable condition [10].
The medical equipment that must be provided in each of the hospital department listed as follow:

4.12.1. Trauma r room

- Ventilator
- DC shock
- Tube feeding pump
- Multi parameter patient monitor
- Infusion pump
- Syringe pump
- Intracranial Pressure Monitor (ICP)
- Central gas panel

4.12.2. Chest disease room

- BiPAP Ventilation System
- Closed-chest drainage device
- Chest tube instruments and supplies
- Emergency thoracotomy instruments and supplies
- End-tidal CO_2 monitor
- Nebulizer
- Peak flow meter
- Patient monitor
- Central gas panel

4.12.3. Infection isolation room

- Multi parameter patient monitor
- Sphygmomanometer
- Stethoscope
- Ventilator
- DC shock
- Infusion pump
- Syringe pump
- Central gas panel

4.12.4. General Examination Rooms

- Mobile examination lamp
- Sphygmomanometer
- Stethoscope
- Finger Pulse oximeter

4.12.5. Child examination room:

Same as general examination room but the child devices must be provided.

4.12.6. Treatment room (minor surgery):

- Surgical mobile lamp
- Electrocautery machine
- Operating table, simple
- Patient trolley
- Stethoscope
- Sphygmomanometer

4.12.7. Operation room:

- Operation table
- Electro surgery
- Multi parameter patient monitor
- Suction
- Dc –shock
- Surgical Endoscopy unit
- Operation ceiling lamp
- Central gas panel

4.12.8. Anaesthesia room:

- Mobile surgical lamp
- Anaesthesia machine

4.12.9. ICU room:

- Multi parameter patient monitor
- Ventilator
- DC shock
- Infusion pump
- Syringe pump
- Stethoscopes and sphygmomanometers
- Electrical patient bed
- Central gas panel

4.12.10. Sterilization unit:

- Automatic sterilizer
- Ultrasonic Washer

4.12.11. Patient room:

- Patient bed
- Syringe pump
- Infusion pump
- Central gas panel

4.12.12. Laboratory:

- Microscope
- Centrifuge
- Water path
- Distiller
- Haematology analyser
- Spectrophotometer
- Samples refrigerator

4.12.13. Blood bank:

- Blood bank refrigerator

4.12.14. X-Ray room:

- X -ray table
- X -ray control

4.12.15. Fluoroscopy room:

- Fluoroscopic x-ray table
- Fluoroscopic x-ray control

4.12.16. Dark room:

- Automatic Film Processor
- X-ray save light

4.12.17. Ultrasound room:

- Ultrasound with printer

4.12.18. CT scan room

Scanning room:

- CT scan device
- Automatic injector

Operation council

- Operation and control device

Power room:

- Power equipment
- Uninterrupted power supply (UPS)

4.12.19. MRI room:

Scanning room

- MR device
- Automatic injector
- Cooling system

Operation council

- Operation and control device

Power room:

- Power equipment
- Uninterrupted power supply (UPS)

4.12.20. Ambulance equipment:

- Stethoscopes and sphygmomanometers
- **Ventilator**
- **DC shock**
- **Patient monitor**
- **Suction unit**
- **Glucometer**

4.13. Financial Aspects

4.13.1. Investment costs framework for new emergency hospital:

The investment costs framework for a hospital is determined by two quantities: the normative floor area and the building costs per m².

The investment costs framework for a new building intended to completely replace a hospital will subsequently be determined by multiplying the total gross floor area (normal + specific functions) by the building price per m² for a hospital as incorporated in the annual note on building costs of international hospital facilities.

By way of illustration, an investment costs framework is determined in the table below on the basis of a fictitious example [13].

Table (4.1): cost analysis of emergency facility building design

	Gross floor area		
	Inpatient 162 m²/1,000 inhabitants	Outpatient 104 m²/1,000 inhabitants	Total
Standard package Inpatient adherency 150,000 inhab. Outpatient adherency 160,000 inhab. Total	 24,300 m²	 16,640 m²	 40,940 m²
PM items			3,000 m²
Total floor area			43,940 m²
Building price per m² *) **Total investment costs framework**			$ 3,296 $ 144.9 mln

The total area in this work about 7380m^2 (93.5m × 80m), so the total hospital building design cost about **<u>24,654,080 USD</u>**.

4.13.2. Medical equipment cost:

The cost of medical equipment is providing to complete the emergency facility financial aspect. It is most difficult step in hospital cost analysis because of the different in medical devices models, manufactures and specifications, so the important way is to choose the best specification with reasonable cost.
The table (2) below show the list of medical devices with quantity and prices in United States Dollar (USD):

Table (4.2) medical devices quantity (Qty) and prices

Medical Device	Qty	Unit Price	Total Price
General x-ray unit	1	130,000	130,000
Fluoroscopic x-ray	1	90,000	90,000
MRI system 1.5T	1	200,000	200,000
CT scan device	1	120,000	120,000
Automatic injector	2	1,500	3,000
X-ray safe light	4	80	320
Automatic Film Processor	1	2,500	2,500
Film Drier	1	400	400
Ultra sound unit(general) with Printer	1	15,000	15,000
Ventilator	6	15,000	90,000
Defibrillator	6	2,500	15,000
Tube feeding pump	10	30	300
Multi parameter patient monitor	20	4,000	80,000
Infusion pump	20	500	10,000
Syringe pump	20	600	12,000
Intracranial Pressure Monitor (ICP)	4	1,000	4,000
BiPAP Ventilation System	1	1,500	1,500
Chest tube instruments and supplies	1	4,000	4,000
Emergency thoracotomy instruments	1	3,500	3,500
End-tidal CO_2 monitor	1	2,500	2,500
Nebulizer	5	400	2,000
Central gas station	1	237,500	237,500
Sphygmomanometer	50	30	1,500
Stethoscope	50	15	750
Mobile examination lamp	5	150	750
Finger Pulse oximeter	10	50	500
Surgical operation lamp	2	2,500	5,000
Patient couch	20	150	3,000
Surgical Operation table	2	4,000	8,000
Electrosurgery	3	600	1,800
Suction machine	3	400	1,200
Surgical Endoscopy unit	1	80,000	80,000

Mobile surgical lamp	2	1,000	2,000
Anaesthesia machine	2	1,000	2,000
Ultrasonic Washer	2	2,000	4,000
Automatic operation sterilizer	2	5,000	10,000
Patient bed	20	900	18,000
Microscope	3	1,200	3,600
Centrifuge	2	450	900
Water path	1	300	300
Distiller	1	250	250
Haematology analyser	1	8,000	8,000
Spectrophotometer	1	4,000	4,000
Laboratory samples refrigerator	1	1,000	1,000
Blood bank refrigerator	1	13,000	13,000
Wheelchair	10	100	1,000
Stretcher and patient trolley	15	300	4,500
Total Medical Devices Cost			**1,198,570**

The total Hospital Cost (building and medical equipment) about

25,852,650USD

4.14. Emergency Hospital Lay Out

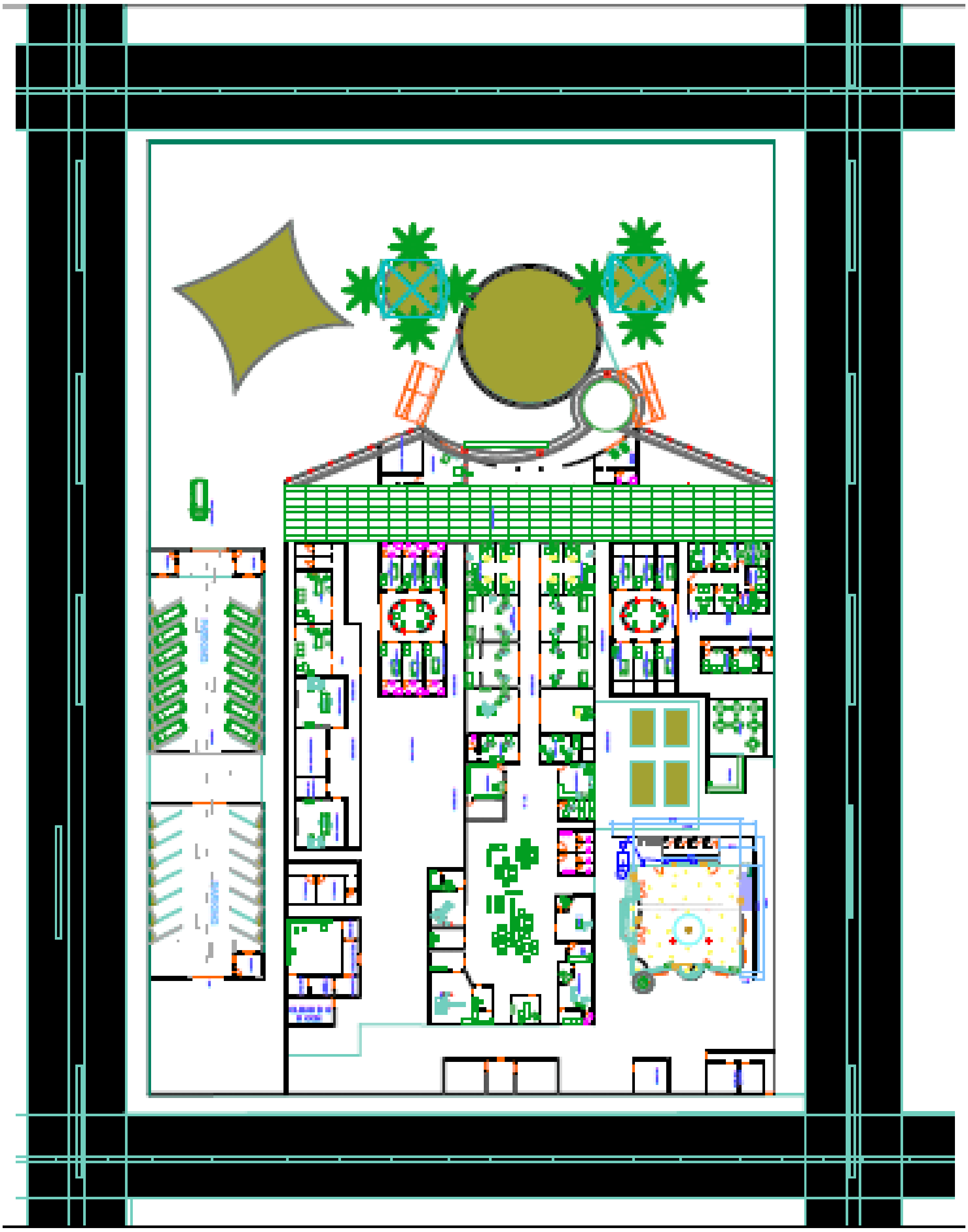

Figure (4.33): emergency facility complete lay out

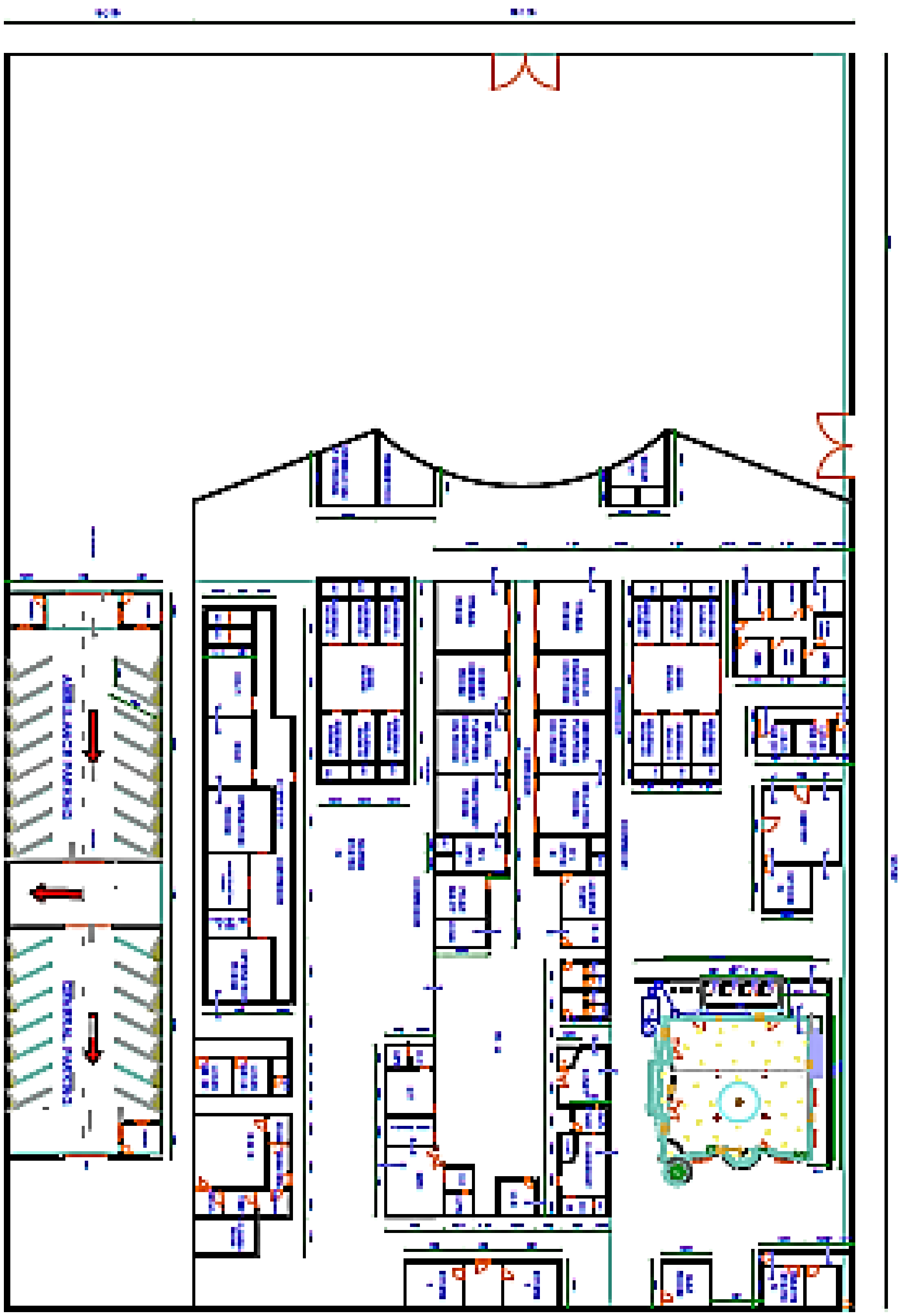

Figure (4.34): Emergency facility plane, departments location and dimensions

The wall section in figure (4.34) 1, 2 and 3 can be represented as cross section in figure (4.35)

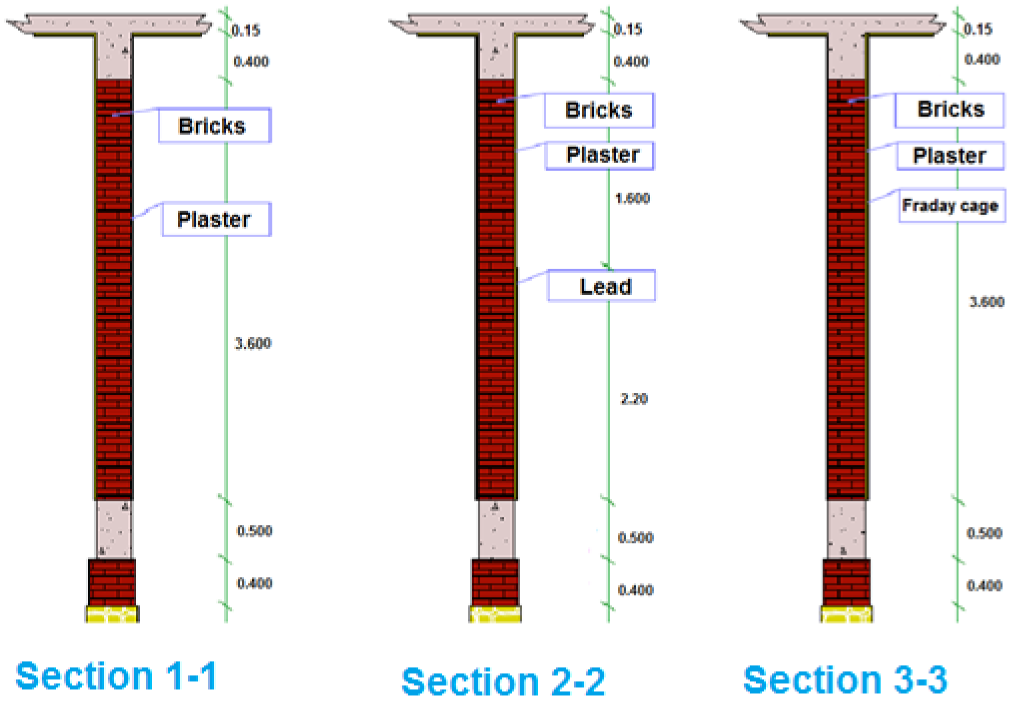

Figure (4.35): types of wall finishing cross sections

4.15 Emergency facility departments and design analysis:

4.15.1 Reception and entry area:

The first and important area in hospital that classified as outer zoon contains of:

1. **Police and security office** if police case occurrence.
2. **Wheelchair and stretcher** storage with professional nurses to receive the patient from the outer gate with proper tools.
3. **Reception counters** to guide the families and visitors.

Figure (4.36) emergency hospital reception

4. **Hot cases rooms:** The location of these rooms must be near to the entry to help the smooth and quick patient entry, there are eight rooms designed parallel and all of these rooms used the same corridor as shown in figure (4.37)

Figure (4.37): hot cases rooms

- **Trauma room:** In this design two trauma room were prepare and equipped with same devices and furniture see figure(4.38), that help to provide additional space to help more patients in same time and then reduce the crowding that usually occur in tradition emergency hospitals. Each room contain of 4 beds and also central nurse station for observation and control the patient traffic and situation.

Figure (4.38) Trauma room: A) out view, B) inside view

- **Examination rooms:** The location of examination rooms directly with trauma room, there was 3 type of examination rooms:

1. General purpose examination room
2. Special purpose examination room
3. Child examination room

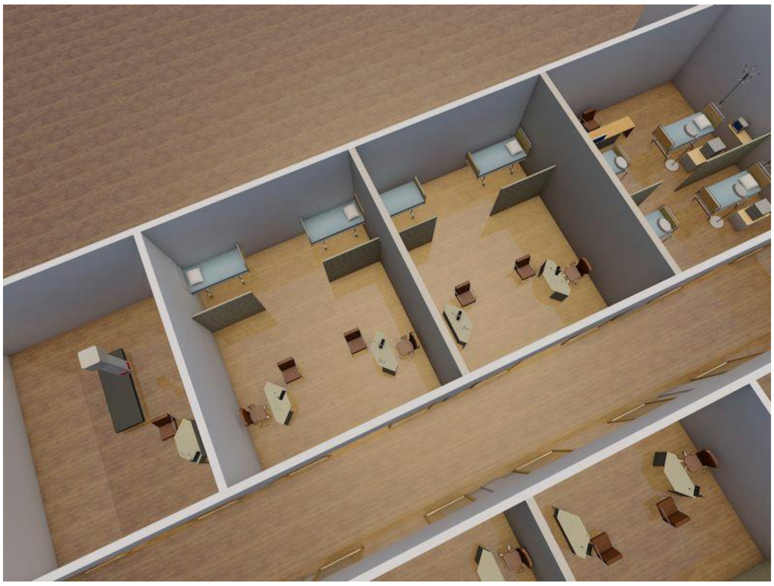

Figure (4.39) examination rooms

- **Chest disease (Thoracic):** This room special for patient who suffer from chest disease because there is need for special equipment that available in this room.
- **Isolation room:** This room was little away from other rooms and completely isolated, it was designed for patients suffer from infectious disease. In this case the room need to periodic disinfection process after each patient leave.
- **Treatment room:** or minor surgery designed to be near to entrance and also near the imaging department, quick and minor surgery is suite in this room, see figure (4.37).

4.15.2 Imaging department:

The imaging department designed of five rooms:

1. **X-ray room:** General and simple x-ray room consist of examination site and small control booth**.**

2. **Fluoroscopy:** Consist of examination room changing room and toilet. The location of the fluoroscopy near to the x-ray room that were separated with dark room to serve booth.

3. **Ultrasound:** The design of this room was very simple and not shielded as other rooms in this department.

4. **CT-Scan**: This room different in design than the other above room it was consist of :
    a. Scanning room: For patient scan.
    b. Operation council: For operator to control scanning process.
    c. Power equipment room: Consist of power equipment and UPS.

X-ray, fluoroscopy and CT scanning rooms was shielded with lead, (see 4.9.5.6.1).

5. MRI: In this site of imaging department the design was different than other room because of different in scanning room shielding and also the cooling system requirement.

The MRI rooms consist of:

– Preparation room: To prepare the patient and ensure the clear of metal inside the scanning room so, the only entrance for patient to the scanning room was through the preparation room.

– Operation council and Power equipment room: As same as in CT rooms.

The location of MRI room designed away from other rooms and department for more protection from inside or to outside.

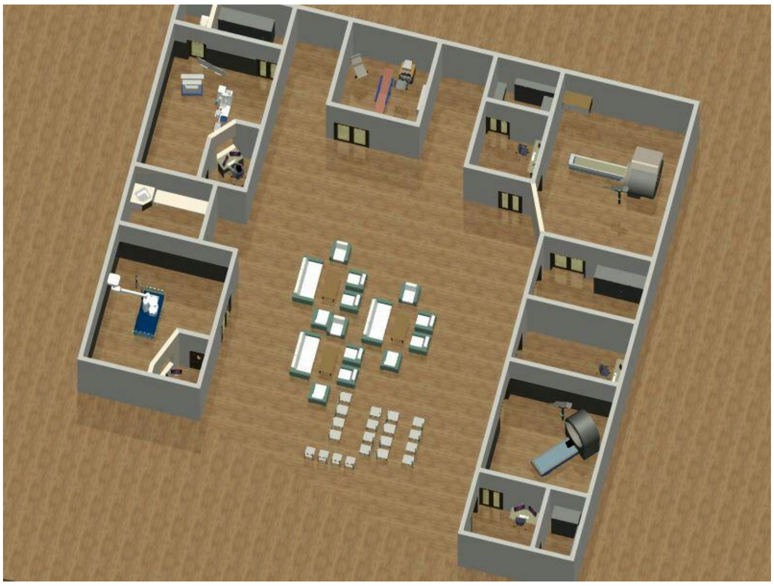

Figure (4.40) imaging department

4.15.3 Patient rooms and nurse station:

The patient rooms department was designed as two sections, the first section designed near to the operation room and ICU department to help patient that need to stay for while after surgery, and the other section located in the other side from hot cases rooms to help the patient in need to stay fore while without series surgery.

Each section consists of six individual patient rooms with personal toilet, all these rooms connected with central nurse station to control and observe all rooms in same time as shown in figure (4.41).

Figure (4.41) patient room: A) patient room inside view, B) central nurse's station

4.15.4 Operation Room and ICU:

One of the important departments in emergency hospital, to provide more help in case of disaster and accident, two operation rooms was designed and equipped with same devices and equipment, and these share same anesthesia room.

The sterilization room also designed near the operation room to provide sterile equipment and clothes used in theater.

This department also consists of two ICU rooms with wide area for multi patient uses; also nurse station counter was designed for ICU observation and monitoring.

Outer of this department there was wide area for patient and nurse traffic and also as waiting area for both operation rooms and ICUs.

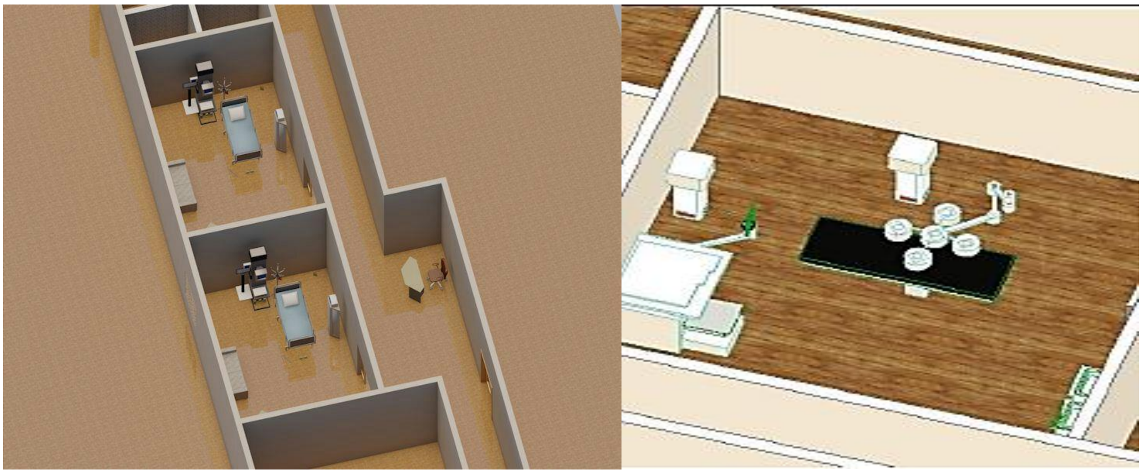

Figure (4.42) ICU in left side and general operation room in other side

4.15.5 Laboratory:

The laboratory in this design was also located in the second zoon near the hot cases rooms for quick diagnostic; it was designed as emergency laboratory provide only the main important tests.

The public toilet and waiting are also designed to serve the laboratory see figure (4.43).

Figure (4.43) laboratory inner view

Figure (4.44) blood bank

4.15.6 Pharmacy:

In this design the pharmacy also one of the second zoon facility, it was located to provide the quick availability of drugs. The pharmacy also contains drug storage, see figure (4.45).

Figure (4.45) pharmacy with drug store

4.15.7 Other 3D layout Images

Figure (4.46): emergency facility full view

Figure (4.47) frontal view

Figure (4.48) mosque

Figure (4.49) administration offices

Figure (4.50) dietary

Figure (4.51) lounge

Figure (4.52) ambulance parking

CHAPTER FIVE

CONCLUSION

Conclusion

In this work has emergency hospital was designed based on the international standards that are globally followed in designing, building and equipping emergency hospitals which do not exist in Sudan and are highly required.

The Emergency hospital was designed in a way that all measures and standards were made to ensure the proper medical attention, care and services are provided to the patient whether during the transportation to the hospital by the ambulance, or from the moment the patient enter the hospital's reception arrived by a private transportation.

The differences between the international standards globally used, and some of the building materials in this thesis is due to the availability of the building materials in local market.

One of the difficulties faced this work was the cost analysis for equipping the emergency hospital. This was due the variety of brands, characteristics and specifications of the medical equipment, therefore differences in prices. To overcome this challenge, the selection was made based on the high quality taking in consideration the life span of the medical equipment under difficult conditions and disasters when hospital receive massive number of patient.

Other challenge also faced this work the variety of the international standard of different hospital department's areas in each reference, to bass through these challenge when the minimum area was used as reference the maximum of these minimums was selected and that to avoid the crowding that all our emergency departments in Sudan suffer from.

In our country we do not have ideal building prepared for emergency, and also there is randomly location selection.

CHAPTER SIX

RECOMMENDATION

Recommendation

Currently in the next phase of development in emergency care and need to move the Emergency Rooms to fully functional Emergency hospital in both structure, system, and design.

- The emergency hospital deigning team must be containing of trained and professional biomedical engineering.
- The hospital location should be selected carefully and never be inside cantons.
- Ambulance should be fully equipped by emergency equipment to be very suite for emergency cases and become the initial care unit.
- Importance of availability of trained an emergency medical staff to receive the patient who arrives to hospital in a special way or ambulance from outside the facility and start the diagnosis until arrives to the examination room.

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APPENDIX

Appendix A

Questionnaire to study the quality of emergency department in Sudan

Hospital Name: …………………………………………… **Date:** …………….

Hospital Type: …………………………………………….

1. Are emergency department area enough for help and serve all patients in emergency cases?

○**Yes** ○ **No**

2. Mostly the department crowding of patients and that may lead to reduced medical services.

○**Yes** ○ **No**

3. How patient arrive to the hospital mostly?

○ **Ambulance** ○ **privet way**

4. How many ambulances fitted to the emergency department?

○**1 – 3** ○ **5- 7** ○ **More** ○ **Not available**

5. The percentage of cases that transform to other hospital

○**100%** ○**75%** ○**50%** ○**25%** ○**0%**

6. Are department contains all medical equipment needed for emergency situations?

○**Yes** ○ **No**

7. If the department is suffering from problems in the maintenance of medical equipment and prepared for emergency situations that may be lead to:

○ **Don't have Biomedical engineering**
○ **Spare parts not available**
○ **High Cost**
○ **No problems**

8. Is there a difficulty in providing medical disposables for emergency cases?

○**Yes** ○ **No**

9. Is there is a sufficient number of trained Emergency Physicians and nurses?

○**Yes** ○ **No**

10. Do you think the department needs to be reworked, whether in design or regulation?

○**Yes** ○ **No**

11. Do you think the emergency department can be more helpful if separate as independent hospital?

○**Yes** ○ **No**