Patient centered architectural design approach for infection control in trauma centers

The case of Aabet and Alert hospitals, Addis Ababa

Submitted in partial fulfillment of the requirements for the degree of Masters in Advanced Architectural Design (MAAD)

By

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DECLARATION

I, the undersigned, declare that this thesis (Patient centered architectural design approach for infection control in trauma centers: The case of Aabet and Alert hospitals, Addis Ababa) is my original work and has not been presented for a degree in any other university, and that all sources of materials used for the thesis have been duly acknowledged.

Signature: _____

Name of the student: _____

Date: _____

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LIST OF ABBREVIATIONS

HAI	Hospital Associated Infection	HCAI	Health Care Associated Infection
IPC	Infection Protection and control	EMS	Emergency Medical Service
MoH	Ministry of Health	A&E	Accident and Emergency
WHO	World Health Organization	CMAJ	Canadian Medical Association Journal
CDC	Center of Disease Control	ED	Emergency Department
ASHE	American Society for Healthcare Engineering	HCP	Health Care Professional
FGI	Facility Guidelines Institute	HFE	Human Factor Engineering
HBN	Health Building Notes	NGO	Non- Governmental Organization
EFDR	Ethiopian Federal Democratic Republic	CSSD	Central Sterile Supply Department
OR	Operating Theatre	ICU	Intensive Care Unit

ABSTRACT

This thesis is aimed to assess the infection risks in trauma hospitals through selecting case study samples and study a design approach and method of implementation to improve the existing infection risk.

As there might be varieties of physical and clinical approaches to control infection in hospital settings, this thesis focused on the physicals aspect of a hospital and tried to identify parameters of patient centered architectural design approach to achieve infection safe hospital setting.

Thesis data is collected through reviewing literature, interview with policy makers, NGOs and healthcare professionals and observation

Aabet and Alert trauma hospitals while being located in the capital, the case study selection is intended to understand the situation with regard to hospital acquired infection (HAI) and design factors that are contributing to the problem.

Following a thorough investigation of the case studies, the collected data was analyzed through the assessment of selected medical and design professionals. The analysis process showed the importance of managing the patient traffic and treatment process flow in and among emergency observation (24 hour observation), emergency procedure and surgical units during design stage.

Finally, it is concluded that the level of HAI can be controlled through patient centered design approach. Strategies such as major patient path identification, giving priorities for the identified treatment flow, planning a layout according to the treatment path for easier triaging, timely transition from each unit to another, minimize crossings other traffic flows and placement of diagnostic facility on average location to the major patient paths are recommended to be considered in patient centered design approach.

Key words: Health care associated infection, infection control, patient centered design, trauma hospitals

CHAPTER 1

1.0 THESIS OVERVIEW

1.1. INTRODUCTION

Healthcare service provision has always been tackled by varieties of problems that compromise the quality of treatment received by patients. One of these problems is healthcare associated infection. Healthcare associated infection (HAI), despite the number of factors for its prevalence, it is a global issue.

Based on a report prepared for WHO in 2011, titled, report on the burden of endemic healthcare associated infection worldwide, it is shown that developing countries have much higher rate of HAI compared to developed countries despite the very scanty information available from developing countries. This level of infection is even more visible in emergency and trauma settings due to the nature of patients and urgent care service delivery.

Ethiopia, being one of the developing countries with few number of dedicated trauma centers, level of HAI in these centers is expected to be high.

Healthcare associated infection can be a result of clinical or physical factor within healthcare setting. But this research work is focused on identifying architectural design related risk of infection and minimize it using patient centered architectural design approach on trauma hospitals through case study means.

This study is structured in seven chapters. The first chapter discusses general ideas how the research is organized, its objective, how the problem is identified with its final goal and limits its study boundaries.

The second chapter discusses background and related studies around the topic while the third chapter discusses contextual review of the country's guidelines, policies and regulations. The fourth chapter discuss about the designed methodology towards identifying the existence of the problem and the causes.

On the fifth chapter collected data is presented, summarized and analyzed to bring output for conclusion and recommendation which will be discussed on the sixth chapter. On the seventh chapter, the studied design approach will be tested through a sample redesign project on one of the case study hospitals.

1.2. RESEARCH OBJECTIVE

General objective

This study sets out to identify the existing gap in infection prevention in trauma centers of emergency departments caused by planning and design flaws using systematically selected representative hospitals in Addis Ababa. The study assesses the patient flow pattern in the existing unit layout and how it is contributing to the infection risk. Analyzing facilities based on the existing local and international guidelines and standards and how much it is account for the occurrence and transmission of infection, and identify if the current international and local standard can be applied to the existing practice and culture of the society and tries to give a solution and recommendation on how to improve the patient flow and minimize the risk of infections through planning and design approach.

Specific objective

- Asses the status of risk of infection around trauma hospitals through selecting major stand-alone trauma service providing hospitals.
- Study the design approach and patient flow pattern and its contribution to infection transmission.
- Propose a design approach and asses the contribution to improve the existing situation of HAI (Hospital acquired infection/ healthcare associated infection) and propose a strategy on how to utilize patient flow based design to control infection.

1.3. PROBLEM STATEMENT

In day to day events people involve in varieties of activities which can result in accident and trauma. Annually, 27 people out of 100,000 experiences fatal road accident in Ethiopia.[1] And vehicle accident being the common contributor, a number of accidents happens every day. These accidents result in large number fatal and non fatal ones and non fatal ones usually end up in trauma hospitals. As much percentage of cars are in the capital Addis Ababa, accidents also happen within the city and the victims will be admitted to the few hospitals which are known for their emergency services.

Treating a trauma conditions involve treating a very dangerous, big and open wound with much bleeding and also burns that can make large part of body surface to be exposed to the environment and infectious organisms, vectors and materials. It also involves much number of emergency surgeries. This condition will lead to a high flow of traffic from staff, material and equipment supply, patient and patient's family (visitors). When this flow is not channeled and organized properly, it can lead to infections which

[1] http:// www.who.int/news-room/fact-sheets

lead to number extended hospital stay, loss of public money and even deaths that could have been saved otherwise.

HAI is a common issue on healthcare settings around the world. This situation worsens on countries with low economy as a result of lack of wide varieties of precautions that had to be implemented within the hospital setting. The causes of HAI within a facility can be a result of design and construction or post design and construction IPC (infection protection and control) issues. The risk of HAI when treating accident and trauma patients is high as a result of an exposed infection prone body parts, large quantity body fluids etc.

Therefore, this study focuses on understanding the impact of patient flow based design approach in planning and design of trauma centers in order to improve HAI.

1.4. HYPOTHESIS

According to a document prepared by ASHE and partners for CDC on 2015 called "infection prevention and control using physical environment", most healthcare related infections primarily come from patients then staff members and transmitted through the different modes of infection transmission. It also states that Patient flow management is a key factor to control infection, improve treatment waiting time, decreased hospital stay etc. Furthermore, Patient flow management includes facilitating patients from arrival through the different levels of care until discharge. It also determines the amount of stay, location of stay and paths to get from one place to another.

Ethiopian national minimum standard for general hospital, Ethiopian comprehensive specialized hospital requirements and FGI 2010 also suggests patient flow is concerned with:

- Proper travel of patients from one place to another or one unit to another keeping the process of medical service
- Properly receiving processing and discharging
- A protocol within a hospital for a proper handling of a patient from arrival to the receiving of proper patient care until discharge. This protocol is also concerned with following of proper path from one place to another without interrupting other important traffic flows. This allows:
    - Manage patients duration if stay at each service
    - Manage risk of accessing restricted areas which minimizes risk of contamination
    - Identifies proper pathways for a safe patient journey and treatment process

Architectural design has a potential of sorting different traffics and providing only the necessary links. Therefore, If the source of most infections are patients themselves and patient flow management have a

potential to improve HAI, then designing facilities with at most focus on the patient flow will have a potential to improve the condition of HAI in hospitals.

1.5. RESEARCH QUESTION

The study sets out to answer the following research questions:

1. How severe is the condition of HAI in trauma hospitals?
2. How often architectural design approach is influenced by infection control principles in trauma hospitals?
3. Can patient centered architectural design approach be a tool to improve condition of HAI in trauma hospitals?

1.6. SCOPE

This research targets trauma hospitals in Addis Ababa, Ethiopia which are going to be studied for their layouts and patient flow management systems and how it is contributing to the existing level of infection. There are varieties of sources of infection in a hospital setting but this study only focuses on the physical which is layout based patient flow contribution.

1.7. LIMITATIONS

Depending on the nature of the research, several obstacles and difficulties can be faced in various levels. The main challenge on this research process is during data collection. Finding published documents was not a difficult task especially the ones from WHO (world health organization) and CDC (center of disease control) but publications and documents prepared by the authorities in the country needed more effort.

Doing an interview with key personnel from the methodologically selected institutions was another challenge. The interviewees were open minded and cooperative while giving information but the way to get to them involved some challenge. Finding the right person in a specific department of a very big institution needed much more effort and time than the necessary which led the researcher to find some informal ways to identify the focal people and use a formal way to communicate with them.

The other one was the case areas, hospitals. Taking a visual inspection was not that difficult but taking pictures and gathering plan layout data while the hospital operating pause another challenge. While taking picture, the researcher had to get to several arguments with patients and families.

Finally, during healthcare design professional selection process for assessment of case hospitals, all six contacted professionals were willing to co-operate and took the assessment formats. But only two

professionals delivered the assessments. The rest were unable to deliver their assessments due to unknown reasons. As a result the researcher is forced to continue the study with assessments at hand.

Furthermore, most previous studies on IPC are focused on clinical issues rather than architectural (physical) issues which this study is focused on and data related to quantitative aspect of HAI, infection and infection source tracking are not recorded in a way that serves a researcher as a leaping platform.

CHAPTER 2

LITERATURE REVIEW

2.0. LITERATURE REVIEW

2.1. INTRODUCTION

This chapter discusses topics that are related to the study. The topics are discussed to understand, give clarification and refer results of other studies and publications in an order of the research question of this thesis work.

Discussions on this chapter are categorized in to seven topics. The first three topics discuss about the characteristics and components of trauma hospital and their situation of HAI. Then the next two topics discuss about the relationship between architectural design and infection control. Then the last two topics discuss about design approaches on hospital design and designing for patient flow.

2.2. HEALTH- CARE ASSOCIATED INFECTION (HAI)

Health- care associated infections (HAI) are the most adverse event in healthcare delivery worldwide. According to WHO fact sheet hundreds of millions of patients are affected by health- care associated infections worldwide each year, leading to significant mortality and financial losses for healthcare system.

“A hospital-acquired infection (HAI), also known as a nosocomial infection, is an infection that is acquired in a hospital or other health care facility. To emphasize both hospital and nonhospital settings, it is sometimes instead called a health care–associated infection (HAI or HCAI). Such an infection can be acquired in hospital, nursing home, rehabilitation facility, outpatient clinic, or other clinical settings. Infection is spread to the susceptible patient in the clinical setting by various means. Health care staff can spread infection, in addition to contaminated equipment, bed linens, or air droplets.

HAI is highly dependent on the facility and healthcare status of the country where the care is given. According to a report by WHO and CDC, of every 100 specialized patients at any given time, seven in developed and 10 in developing countries will acquire at least one health care associated infection.

The endemic burden of health-care associated infection is also significantly higher in low and middle income than high income countries.

Furthermore, while urinary tract infection is the most frequent health- care associated infection in high income countries, surgical site infection is the leading infection in setting with limited resources (low income) countries affecting up to one- third of operated patients. This is up to nine times higher than in developed countries. Other source of infection is device related. This mode of transmission is three times higher in developing countries than in developed countries.

In the United States, the Centers for Disease Control and Prevention estimated roughly 1.7 million hospital-associated infections, from all types of microorganisms, including bacteria and fungi combined, cause or contribute to 99,000 deaths each year. In Europe, where hospital surveys have been conducted, the category of germ-negative infections are estimated to account for two-thirds of the 25,000 deaths each year.

2.3. SOURCE AND TYPE OF HAI

According to WHO, prevention of hospital- acquired infection, Infection can originate from the outside environment, another infected patient, staff that may be infected, or in some cases, the source of the infection cannot be determined. In some cases the microorganism originates from the patient's own skin microbiota, becoming opportunistic after surgery or other procedures that compromise the protective skin barrier. Though the patient may have contracted the infection from their own skin, the infection is still considered nosocomial since it develops in the health care setting. (WHO, 2017)

HAI can be transmitted through different modes and the major ones according to CDC are:-

- Contact transmission
    - Direct contact
    - Indirect contact
- Droplet transmission
- Airborne transmission
- Common vehicle transmission
- Vector borne transmission

Based on infection site, WHO categorizes infection in the following types:

- Urinary infections
- Surgical Site infection
- Nosocomial pneumonia
- Nosocomial bacteria
- Other nosocomial infections

Out of the infection types, Surgical site infection is the most common type of infection on developing countries like Ethiopia.

2.4. ACCIDENT AND TRAUMA HOSPITAL

A coordinated emergency medical service (EMS) system designed to provide rapid assessment of victims of severe or multisystem trauma, transport to a trauma center, and definitive care. It may involve air medical transport. [2]

Another definition of a trauma hospital according to Wikipedia:

> *"A **trauma center** (or **trauma centre**) is a hospital equipped and staffed to provide care for patients suffering from major traumatic injuries such as falls, motor vehicle collisions, or gunshot wounds. A trauma center may also refer to an emergency department (also known as a "casualty department" or "accident & emergency") without the presence of specialized services to care for victims of major trauma."*[3]

Emergency care ranges from initial emergency care to definitive emergency care as per the definition of facility guideline institute (FGI) standard 2010 edition. It also state initial and definitive emergency care areas must be able to provide services 24 hours a day, 7 days a week.

Initial emergency care is provided to stabilize a patient's condition and to minimize potential for deterioration during transport to an appropriate facility. Patients may be brought to the "nearest hospital," which may or may not have a dedicated emergency department. In those cases, it is important that the hospital be able to assess and stabilize emergent illnesses and injuries and arrange for appropriate transfer.

Definitive emergency care is care that takes place within a dedicated emergency department. This care may range from suturing lacerations to full-scale emergency medical procedures. Facilities that include personnel and equipment for definitive emergency care provide care leading to discharge to the patient's home or admission to the appropriate hospital.

2.5. RISK OF HAI IN ACCIDENT AND EMERGENCY HOSPITALS

Accident & emergency (A&E) is unique in that patients of all ages are guaranteed access to emergency care 24 hours a day, 7 days a week. Almost 20 million new patients attend A&E in England each year. This number is rising by between 5 and 7% per annum in line with an increase in the acuity of the patient case mix which is one of the aggravating factors for increased risk of infection. Furthermore, emergency service involves various unidentified acute cases which can be a cause for HAI but again this admitted

[3] Medical dictionary 2018 edition
[3] Wikipedia 2019

patients usually come with open wounds, bleeding and various infection prone parts. This makes emergency setting a focal point on infection control.

Emergency departments are high-risk areas for disease transmission because they are often overcrowded, and infectious or susceptible patients may wait in proximity to one another for several hours. In *CMAJ* article, Quach and colleagues report a 3.9 odds ratio for the risk of gastrointestinal and respiratory infections among elderly residents of long-term care facilities following a visit to the emergency department. Similar findings have been described in other populations.

> *"Infections associated with health care are an important health risk. A recent survey by the World Health Organization reported that 8.7% of patients in hospital developed such infections. The third leading cause of death in the United States is health care–associated deaths, with over 100 000 people dying from infections associated with health care each year. In Canada, a point-prevalence survey found that 11.6% of adults in hospital experience a health care–associated infection." (Quach et.al 2015)*

During the study period, 424 residents visited the emergency department were matched to 845 residents without visits to the emergency department for reasons other than possible gastrointestinal or respiratory infection and were not admitted to hospital. The baseline characteristics of both groups were similar, except that, compared to those who did not visit the emergency department; more residents who visited the emergency department dined in their own room and had visitors during the study period. Those who visited the emergency department had higher average scores on the Charlson Comorbidity Index than those who did not visit the emergency department (6.1 v. 5.5; $p < 0.001$).

2.6. COMPONENTS (SERVICES) OF ACCIDENT AND TRAUMA HOSPITALS

According to facility guidelines institute (FGI2012), the following are the essential services within trauma settings.

The extent and type of emergency service to be provided depends on community needs and the availability of other services in the area.

1. Initial emergency services shall be available at every hospital.

2. All services need adequate equipment and 24-hour staffing to ensure no delay in essential treatment.

3. The functional program shall determine the additional type, size, and number of services needed.

1. Initial Emergency Management

General

(1) At a minimum, each hospital shall have 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 stabilization prior to transport to other facilities.

(2) Provisions for initial emergency management shall include the following:

Entrance

(1) A well-marked, illuminated, and covered entrance shall be provided at grade level. The emergency vehicle entry cover shall provide shelter for both the patient and the emergency medical crew during transfer between an emergency vehicle and the building.

(2) Emergency department ambulance entrances shall provide a minimum of 6 feet (1.83 meters) in clear width to accommodate bariatric stretchers, mobile patient lift devices, and accompanying attendants.

(3) If required by the functional program, bariatric lifts shall be available in the covered ambulance bay and positioned to provide assistance with patient transfers.

Reception, triage, and control station.

This shall be located to permit staff observation and control of access to the treatment area, pedestrian and ambulance entrances, and public waiting area.

Public waiting area

Provisions shall be made for public waiting, including the following:

(1) A public toilet with hand-washing station(s)

(2) A telephone

Communication center

Communication connections to the regional emergency medical service (EMS) system shall be provided.

Treatment room

At least one treatment room shall be provided in accordance with Section 2.1-3.2 (Examination/Treatment Room or Area).

(1) Multiple-bed treatment rooms shall have cubicle curtains for privacy.

(2) Each treatment room shall contain the following

a. A work counter

b. Space for medical equipment as specified in the functional program

c. Cabinets

d. Medication storage

e. Adequate electrical outlets above floor level

Patient toilet

A patient toilet room with hand-washing station(s) shall be provided convenient to the treatment room(s).

Equipment and supply storage

Storage shall be provided for general medical/surgical emergency supplies, medications, and equipment (e.g., a ventilator, defibrillator, splints, etc.). This storage shall be located out of traffic and under staff control.

2. Definitive Emergency Care

General

Where a health care organization provides definitive emergency care, facilities shall be provided to accommodate the type, size, and number of services as defined in the functional program. At minimum, the facilities outlined in this section shall be provided.

Entrance

(1) A well-marked, illuminated, and covered entrance shall be provided at grade level.

(2) This entrance shall provide direct access from public roads for ambulance and vehicle traffic.

(3) Paved emergency access to permit discharge of patients from automobiles and ambulances and temporary parking convenient to the entrance shall be provided.

(4) Entrance and driveway shall be clearly marked, and directional signage shall be visible from all public vehicle entrances.

(5) If a raised platform is used for ambulance discharge, a ramp shall be provided for pedestrian and wheelchair access.

(6) The emergency vehicle entry cover shall provide shelter for both the patient and the emergency medical crew during transfer between an emergency vehicle and the building.

(7) The emergency vehicle bays shall be sized so they are compatible with horizontal and vertical vehicle clearances of regional EMS providers.

Reception, triage, and control station.

The emergency department shall be designed to ensure that emergency medical staff and hospital security personnel maintain control of access at all times. In the event of a disaster, terrorist event, or infectious disease outbreak, the emergency department and its exterior perimeter must remain under the control of the hospital to ensure the continued availability of the emergency department as a resource.

(1) Reception, triage, and/or the control station(s) shall be located to permit staff observation and control of access to the main entrance to the department, pedestrian and ambulance entrances, the public waiting area, and the treatment area.

(2) Public access points to the treatment area shall be under direct observation of the reception and control or security function.

(3) The triage area requires special consideration.

(a) The area shall be visible from the reception, triage, or control station to permit observation of patients waiting for treatment.

(b) As the point of entry and assessment for patients with undiagnosed and untreated airborne infections, the triage area shall be designed and ventilated to reduce the exposure of staff, patients, and families to airborne infectious diseases.

2.7. INFECTION CONTROL STRATEGIES IN HOSPITAL DESIGN

In 2015 CDC has published a document for a best Practice Guide to Help Health Care Organizations Create Safe, Healing Environments. The publication is titled “Using the Health Care Physical Environment to prevent and Control Infection”. This publication explores six important topics related to infection prevention and control through the physical environment. Which are:

- Infection control risk assessment
- Hand hygiene infrastructure
- Reprocessing
- Cleaning of environmental surfaces
- Water-related environmental infection control
- Flow of patients, personnel, equipment and waste

Out of these topics this research focuses on the last one which specifically is the patient flow.

The traffic flow strategy in this publication states, the risk of infection transmission in a hospital can be reduced by a number of strategies, including proper configuration of space, airflow design that minimizes the spread of pathogens, and design features that ensure the optimal flow of people and material to

minimize cross contamination. Separating patients who are actively ill with an infectious disease from other patients either through isolation or barriers is an important component of infection prevention. Consequently, designing spaces such airborne infection isolation rooms is important. Another way to limit the spread of infection is the development of "respiratory hygiene/cough etiquette," protocols which encourages patients and visitors with a cough or fever to cover their cough with tissues and to perform hand hygiene. This is especially important in emergency departments, where patients and their families often wait together for long periods of time and infectious patients may not be recognized immediately. Providing barriers for worker safety at triage entry is an example of design considerations to support infection prevention.

"Hospital design may help improve patient safety directly by reducing nosocomial infections, patient falls, medication errors and, sometimes, even by reducing patient morbidity and mortality. Hospital design may also help improve patient safety indirectly by reducing staff stress, staff walking and patient transfer, and by improving hand washing compliance. In contrast, very little has been reported recently on the role of hospital design as a barrier to adverse events in hospitals. While research on the links between hospital design and safety has grown over the last few years, there is still a need for more focused studies. Meanwhile, the growing body of evidence in the field may already have an impact on how hospitals should be designed in the coming years." (Joseph, 2007)
Bross and Carvalho (2002) agree in saying that the role of the architect goes beyond the architectural project, it is necessary to have a global vision of the institution and participate in all stages, including decision-making; therefore, the architect does not constitute in an accessory or absent part of the planning stage.

According to a research conducted by Ana Carolina Potier Mendes et. al. in Brazil, the necessity of the involvement of the architect in hospital design is studied with a systematically selected professional interview method. This study bases leaps from literature summarized as:-

> The process of hospital planning is complex and developed by a multidisciplinary team. Such complexity and demand of a multidisciplinary team should have the architect as the coordinator for being "the only one capable of overcoming the limits of the particularized vision of each of the professionals involved ". In many developing countries, where there are few consultants, this function is often fulfilled by the administrator of the institution or by a medical authority.
> Then as a finding it states:
>
> The architect participation is important and must occur from the beginning of hospital planning, once he/she helps to clarify the logic of space and its program and area organization. It is

observed the architect preoccupation in not acting as a simple drawer, but to discuss the proper viability of the hospital, which requires specialized knowledge and constant professional actualization.

Internationally, there are different design guidelines that are prepared for the architect and other professional to follow as a minimum requirement while designing a hospital and health institutions. These standards are prepared to improve the final output of the planners and designers from different perspectives. Among those controlling the spread and transmission of infection is one of those. This part of the study reviews some of the standards for infection control strategy.

Health building note 00-09(HBN 00-09) deals with infection control in built environment and discuss the following points as a consideration while designing a healthcare facilities.

- **Design to facilitate cleanliness & cleaning**
  - Use finishes that are impervious, smooth and seamless, as far as practicable.
  - Run hard flooring up the walls for a short distance to provide an easy-to-clean coving.
  - Eliminate or minimize dead-legs and blind ends in water systems, both in the original design and as the systems are modified.
  - Consider hands-free operation of utilities (for example, sensor taps, automatic lights, movement sensors for toilet flushes etc).
  - Consider integral blinds as an alternative to curtains at internal windows.
- **Encourage desired behavior (for example, tidiness, hand hygiene)**
  - Provide sufficient space for activities to take place and to avoid cross-contamination between adjacent bed spaces.
  - Ensure proper segregation and management of waste, including clinical waste and linen.
  - Provide sufficient domestic waste receptacles.
  - • Provide bedside waste disposal facilities for patient use.
  - Design-out unnecessary horizontal surfaces (for example, window sills) in order to discourage clutter.
  - Provide enough wash-hand basins and antimicrobial hand-rub dispensers.
  - Plan for and deliver good separation of clean and dirty activities.
  - Provide sufficient space for storage and preparation of cleaning equipment and materials.
  - Provide suitable facilities for cleaning of equipment.
- **Design for easy cleaning**
  - It is always best practice to maintain a visibly clean environment that is free from dust and soilage, and acceptable to patients, their visitors and staff.

- Good design can make cleaning immeasurably easier, for example:
- Use finishes that are easy to clean.
- In clinical areas, flooring should be seamless and smooth, slip-resistant, easily cleaned and appropriately wear-resistant.
- Use threshold matting on all external entrances. The type should allow for expected through traffic and easy cleaning.
- Supply pipe work should always be concealed.
- There may be pressure to choose the cheapest products/design. Attention to whole-life costs, including the costs of cleaning and maintenance, is important. Consult with the IPC team before purchase/on planning.

2.8. EMERGENCY HOSPITAL DESIGN APPROACH

The physical design and infrastructure of a hospital or institution is an essential component of infection control measure. Thus, it must be a prerequisite to take these into consideration from the initial conception and planning stages of the building. The balance between designing a hospital to be an open, accessible and public place and the control to reduce the spread of infectious diseases is a necessity. Based on reports from CDC, At Singapore General Hospital, many lessons were learnt during the SARS outbreak pertaining to this. During and subsequent to the SARS outbreak, many changes evolved in the hospital which enabled the field to handle and face any emerging infectious situation with calm, confidence and the knowledge that staff and patients will be in good place. (Lateef, 2009)
A rigorous application of sets of infection control measures, including isolation, may significantly reduce the risk of disease transmission in emergency departments, thus protecting health care workers, patients and visitors. It should be included in all basic sets of indications for the management of community-acquired pneumonia in emergency departments.

2.9. PATIENT CENTERED DESIGN APPROACH

Patient-centered care has become a phrase repeated often as one of the tenets of successful healthcare delivery. It is used differently in different context. Clinically it is used to refer the medical and psychological treatments that patients get since their arrival at the gate of hospitals. In facility design it is used to address different aspects of the built environment starting from special layout to utilization of physical factors to the healing process. It also evolves creating opportunity for use of technology by the patients to control their own environment.

Article written by J**ennifer Silvis** in 2013 for healthcare design magazine states three consideration for effective patient centered design.

1. **Unit configurations and layout**

   When considering which approach from a race track configuration to a compact triangle designers should measure which model creates an optimal environment for staff travel distances, patient safety, patient visibility and easy communication with staff, proximity of patient rooms to nurses' stations, standardization in same-handed configurations, and use of on-stage/off-stage areas, along with the pros and cons for varying approaches to each.

2. **Decentralized nursing**

   While the traditional approach of using a centralized model has long been a design staple, research supports the move toward a decentralized (or possibly a hybrid of centralized and decentralized) stations that can improve staff efficiency, reduce walking distances, and increase the time nurses can spend with patients. However, one drawback may be a sense of isolation felt by the staff. And when laying out these areas, the paper also reminds that another consideration in this scenario should be the integration of health information technology in workspaces.

3. **Family-centered care**

   Since patients' health is often linked to the health of their family members, creating spaces where relatives can have a sense of self-efficacy and empowerment is a significant component of patient-centered design. The paper explores four key concepts to family-centered care: active participation of patients and family in the healthcare decision-making process; relevant information provided to patients and their family to make those decisions; a choice offered on what level of participation is preferred in decision-making; and involvement on institutional issues, including facility design and delivery of care. Specific design elements supporting family-centered care include single-family rooms with family accommodations.

2.10. PATIENT CENTERED DESIGN FOR INFECTION CONTROL IN ED

Emergency department (ED) crowding occurs when the demand for emergency services exceeds the ability to provide care in a reasonable amount of time. In 2002, the American College of Emergency Physicians defined crowding as:

> *"A situation in which the identified need for emergency services outstrips available resources in the ED (Emergency Department). This situation occurs in hospital EDs when there are more patients than staffed ED treatment beds and wait times exceed a reasonable period. Crowding typically involves patients being monitored in non-treatment areas (e.g. hallways) and awaiting ED treatment beds or inpatient beds. Crowding may also involve an inability to appropriately triage patients, with large numbers of patients in the ED waiting area of any triage assessment category"* (Ivy S Cheng 2016)

This publication further describes the overcrowding situation as not only due to insufficient bed but also improper utilization of resources such as:

> *Insufficient hospital beds are another myth held by many healthcare providers. A common hospital frustration is that they "do not have enough beds", but the fact is in most hospitals, even when there is waiting either in the ED, admitting area or a private physician's office for an inpatient bed the patient ultimately gets to a hospital bed. Very few patients are transferred to another hospital in order to access an inpatient bed. This clearly demonstrates that actual capacity itself is not the problem but rather there is a misaligned capacity as compared to demand.* (Ivy S Cheng 2016)

When hospitals suffer from overcrowding, quality of care becomes far from satisfactory, infections and readmission rates increase, and clinicians burn out as they struggle to support a required level of patient safety. All this takes place in an environment of increasing health care costs.

In 2010 Joint Commission Resources published Managing Patient Flow in Hospitals: Strategies and Solutions, Second Edition. This book introduced the concept of streamlining hospital patient flow. Ten years later, there is a growing demand for a systematic, scientific, and practically proven approach to not only streamlining but also optimizing patient flow to improve care and reduce costs.

Designing "flow" in a health care setting also can reduce the spread of infection. For example, emergency departments may be designed with "pods" and zones and may include procedures that allow for triage "flex" to accommodate changes in patient volume. Creative use of barriers can help when crowding may present a challenge. Design should also consider the movement of environmental waste in the hospital, so that it can be removed and disposed of without the risk of pathogen spread.

Furthermore, it summarizes the following to be among the best practices in hospital design for reducing the spread of infection as follows:

- Consider designing an all isolation room/area that enables unidirectional flow of health care professionals (HCP) entering/exiting for patients with highly infectious diseases.
- Use Human Factors Engineering (HFE) methods to analyze tasks as they are performed in existing spaces. Ask "what design features contribute to the lack of compliance". Work with HCP to design spaces/systems that support efficient workflows for HCP to access clean supplies while still protecting clean and sterile supplies from contamination.
- Remember that the separation of clean and dirty functions to limit cross contamination is fundamental to infection prevention.
- In areas designed to control airborne contaminants, ensure the ventilation system provides appropriate pressure relationships, air-exchange rates, filtration efficiencies, temperature and relative humidity.
- Provide space outside of clinical areas for removal of supplies from external shipping boxes.

It also states, expanding space and adding capacity alone may not improve patient flow in the emergency department, as was identified in a study that looked at administrative data in the period before and after expansion of an emergency department in an academic medical center and in conclusion, the increased capacity was associated with no significant change in the percentage of patients who left without being treated and had an unintended consequence of an increase in emergency department's boarding hours.

An article about using data to drive the design of emergency departments attempted to synthesize the growing data regarding emergency department operations. The author proposed that emergency departments can optimize their functioning by marrying good processes to good design. The article summarizes novel ideas to managing patient flow in the emergency department including the use of pods and zones and ideas such as a "low flow/high flow" model where both the space and operational procedures for triage "flex" to accommodate changes in volume.

Another example of a specialized environment designed to isolate and protect vulnerable patients is an operating room. The risk of surgical site infection is reduced with the use of positive pressure to ensure that air flows from the operating room to adjacent spaces, plus a high number of air changes per hour to remove particulates and an air supply design that distributes air over the surgical field in a specific way. In addition, minimizing traffic in the operating room reduces the volume of airborne particulates that could potentially contribute to surgical site infections.
Healthcare buildings are also constrained by the process-driven activities of stakeholders (Wurzer, 2013).

Patient process flow based analysis is a common healthcare system approach to understand the complexity of various stakeholders' organizational processes. When patient process flow is successfully improved, the process of the overall operational system will also be improved (Potisek, et. al., 2007).

2.11. MAPPING PATIENT FLOW IN TRAUMA HOSPITALS

Mapping patient flow is a widely researched area of study and some are focused on preparing a gap for redesigning the hospital layout.

According to (Martin et. Al. 2010), a research done for mapping patient flow in a regional Australian emergency department, it used a mixed method which is seminar, mapping exercise using data collectors and focus group interview for their observation. Then data collected with the three methods is analyzed to come up with a model for the process. The process then mapped on UML activity diagram and shows the result on the figure 1 below.

On another study made at john Hopkins children's hospital by Durojaiye et.al. 2018, a patient flow mapping is done in order to identify and characterize the major patient pathways and care transitions, and to identify opportunities for patient flow and triage improvement. This study uses data from trauma registry level to identify the major two trauma activation level and then used qualitative methods to identify patient paths. As a result top five patient pathways are identified which are responsible for more than 90% of the patient movements. Figure 2 below shows the mapping generated as a result of the analysis of the collected data.

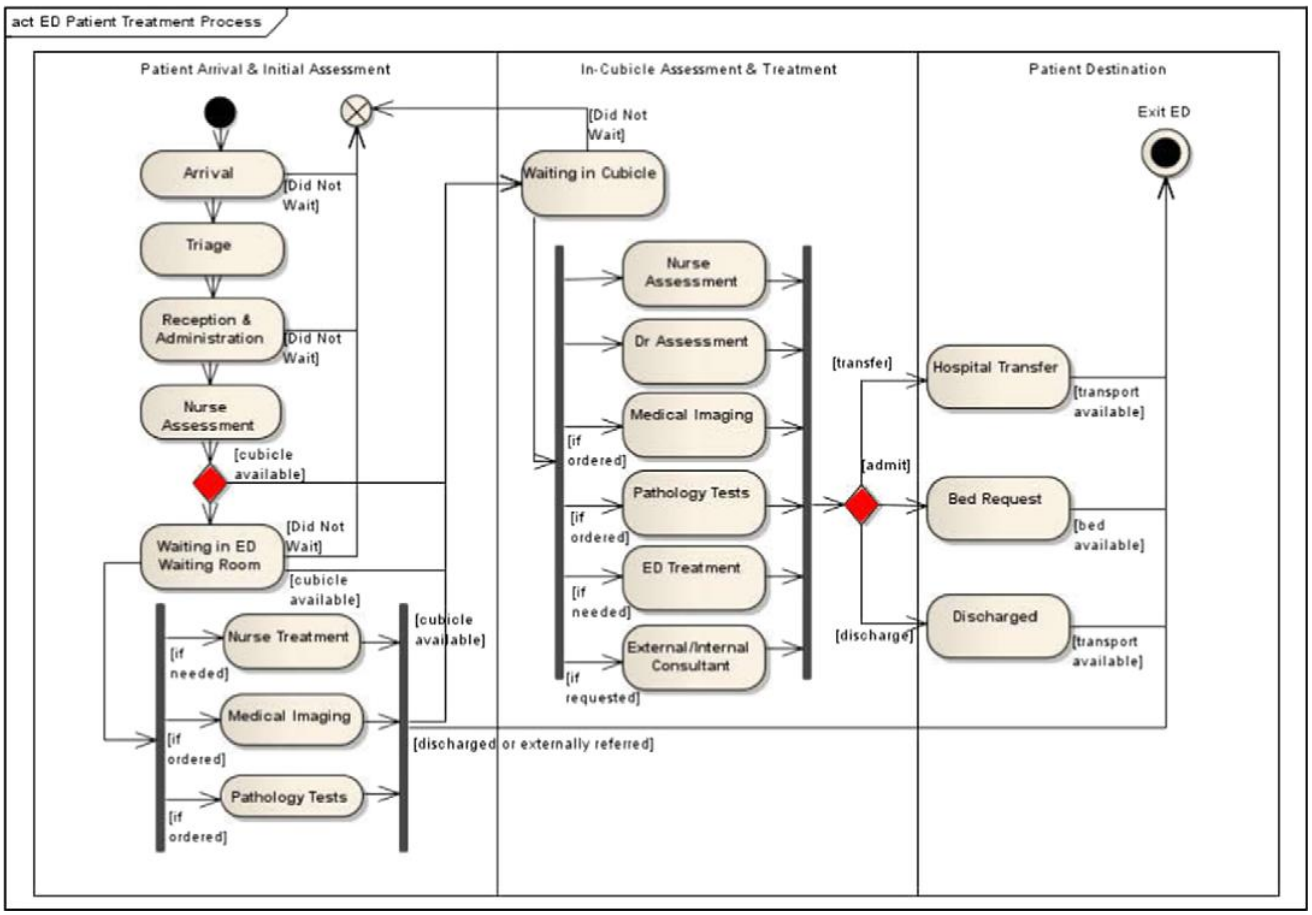


Fig: 1. UML activity diagram for patient journey in Bendigo Health ED. (Martin et. Al. 2010)

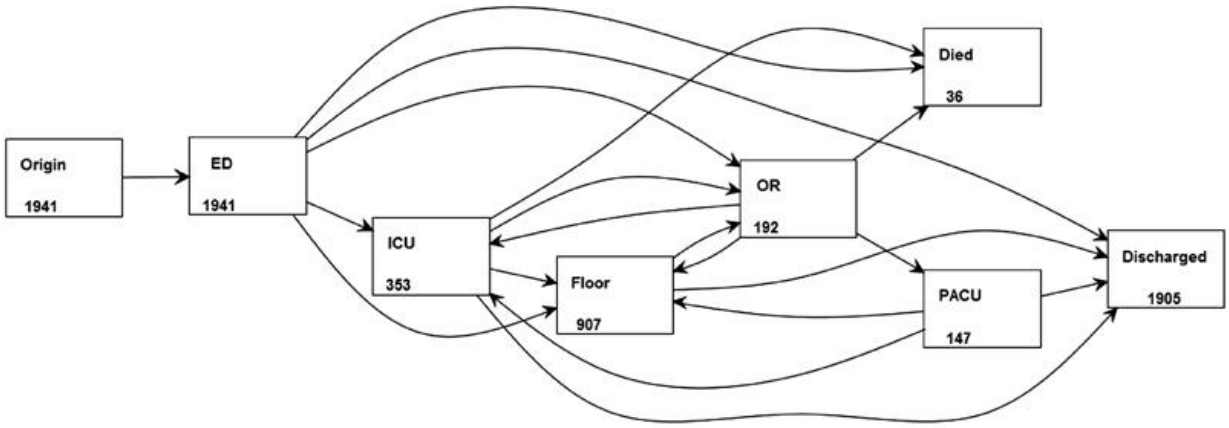


Fig. 2. The process map of cohort showing the flow of patients from arrival to discharge. The numbers in the boxes are the total number of admissions in that inpatient location. ED, emergency department (pediatric ED in this study); ICU, intensive care unit (pediatric ICU in this study); OR, operating room; PACU, post anesthesia care unit.

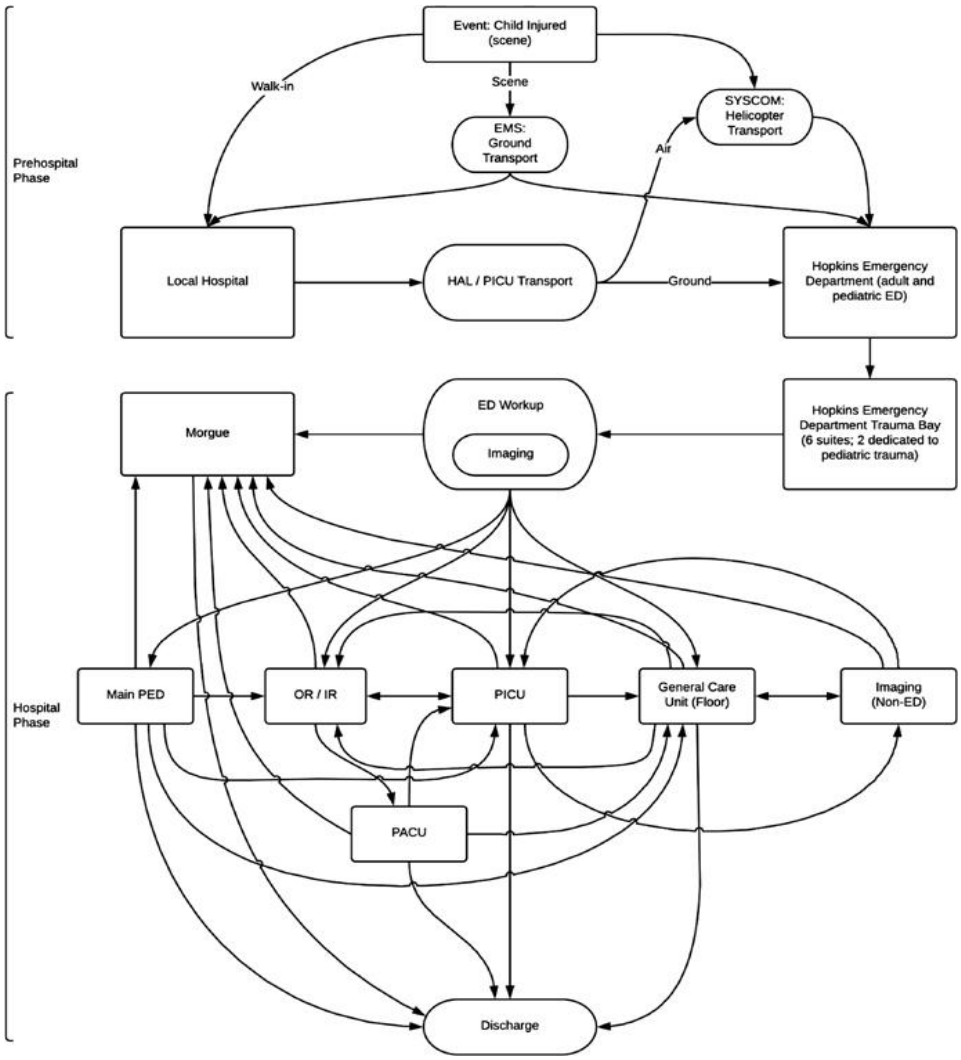


Fig. 3: Process map.

2.12. LITERATURE REVIEW SUMMARY

According to the referred literature, the first three topics show the generally high condition of HAI using documents from WHO, CDC and research by Quach et.al. 2015. This condition is shown to be even more serious on trauma hospitals.

The following two topics showed how architectural design can play a role on preventing and controlling infection on hospital settings through reviewing guidelines and publications from CDC and FGI. Furthermore, publications by Joseph, 2007 and Mendes et.al., 2010 are reviewed for their scholarly identification of the relationship between architectural design and patient safety.

The remaining four topics discussed about patient flow identifications, patient centered design approach and their utilization in designing facilities. Publications by Martin et. al., 2010 and Durojaiye et.al., 2018 are discussed for their assessment of case hospital in order to produce major patient path and flow mapping data which can be an input for increasing efficiency. Additionally, publications on emergency hospital design approach, infection control strategies while designing hospital and patient centered strategies by different scholars are discussed.

Therefore, this chapter discussed about literatures that show the gravity of HAI, architectural design and patient centered design approach and mapping patient paths in case hospitals can be a tool to control infection in trauma centers.

CHAPTER 3

CONTEXTUAL REVIEW

3.0. CONTEXTUAL REVIEW

3.1 INTRODUCTION

This chapter discusses about case area (Addis Ababa, Ethiopia) related literature, policies and strategies based on the research question. It is divided in two topics. The first topic discusses about studies of HAI in Ethiopia while the second discuss about policies and strategies for infection prevention.

3.1. HEALTH- CARE ASSOCIATED INFECTION IN ETHIOPIA

Two studies from different places in Ethiopia are reviewed to see the status of HAI in Ethiopia. Both studies share similar projection about the status of HAI in Ethiopia being a hardly studied area. Furthermore, they took similar sample size and study approach to come up to their conclusion as shown below.

The objective of this study was to examine the nature and extent of HAIs in Ethiopia through a repeated cross-sectional study conducted in two teaching hospitals. All eligible inpatients admitted for at least 48 hours on the day of the survey were included.

The survey was conducted in dry and wet seasons of Ethiopia, that is, in March to April and July 2015. 0ut of a total of 908 patients which were included in this survey with a median age of 27 years (interquartile range: 16-40 years), there were 135 patients with HAI, with a mean prevalence of 14.9% (95% confidence interval 12.7-17.1).

Culture results showed that Klebsiella spp. (22.44%) and Staphylococcus aureus (20.4%) were the most commonly isolated HAI-causing pathogens in these hospitals. The association of patient age and hospital type with the occurrence of HAI was statistically significant.

Finally the study concluded that the prevalence of HAI was high in the teaching hospitals. Surgical site infections and pneumonia were the most common types of HAIs. Hospital management should give more attention to promoting infection prevention practice for better control of HAIs in teaching hospitals. (Worku et. al 2016)

On another study, the situation of HAI is summarized as follows:

This study stresses to assess the alarmingly increasing situation Healthcare associated infection (HAI) in low income settings. In Ethiopia, few HAIs studies focused on point prevalence are available since 1988. Many of these were limited to postoperative HAIs with estimated prevalence of 11% to 36%. Surgical site, urinary tract and blood stream infections were found to be commonest forms. The type of surgery,

patients' underlying medical conditions and the type of the ward were found to be important factors associated with increased risk of HAI in Ethiopia.

The study uses longitudinal study method that was conducted from May to September, 2016. All wards of Jimma University Medical Centre were included to determine the incidence, prevalence and risk factors of healthcare associated infection. A total of 1015 admitted patients were followed throughout their hospital stay.

In conclusion the study revealed high burden and poor discharge outcomes of healthcare associated infection at Jimma University Medical Centre. There is a difference in risk factors between patients with and without surgery. Hence, any effort to control the observed high burden of HAI at the hospital should consider these differences for better positive output. (Solomon Ali et. al, 2018)

3.2. INFECTION PREVENTION GUIDELINE

Based on Federal Ministry of Health Ethiopia Disease Prevention and Control Department, infection prevention guideline, infections from hospital traffic flow can be controlled with the following methods.

Microbial contamination is minimized by reducing the number of people permitted into an area and by defining the activities that take place there.

The traffic flow should be limited in procedure areas, surgical units, and work areas (where instruments are processed. These include dirty and clean areas where soiled instruments, equipments and other items are first cleaned and then processed and stored.). It is important to direct activity patterns and traffic flow in above-mentioned areas to keep contaminated areas separate from areas where procedures take place.

The space, equipment, and need for a well defined traffic flow and activity pattern become progressively more complex as the type of surgical procedure changes from general surgery and obstetric to open heart surgery.

The space requirements for these facilities are:

- Changing room and scrub area for clinic staff
- Preoperative area where clients are examined and evaluated prior to surgery
- Operating room
- Recovery area for patient observation after surgery (may be combined with the preoperative area)
- Processing area for cleaning and sterilizing or high-level disinfecting instruments and other items
- Space for storing sterile packs and/or high-level disinfected containers of instruments and other items

The recommended infection prevention practices for minimizing microbial contamination of specific areas in healthcare facilities are briefly described below.

PROCEDURE AREA

- Limit traffic to authorized staff and patients at all times.
- Permit only the patient and staff performing and assisting with procedures in the procedure room. The number of trainees should be kept to minimum possible.
- Patients can wear their own clean clothing, if not so, healthcare facility may provide cloths. However, for the patients undergoing major surgical procedures, healthcare facility should provide hospital clothes.
- Staff should wear attire and personal protective equipment according to the procedure performed.
- Have a covered container filled with a 0.5% solution for immediate decontamination of instrument and other items once they are no longer needed.
- Have a leak proof, covered waste container for disposal of contaminated waste items.
- Have a puncture-resistant container for safe disposal of sharps at point of use.
- Have storage space in procedure rooms for clean, high-level disinfected and sterile supplies.

SURGICAL UNIT

The surgical unit is divided into four designated areas, unrestricted area (a point through which staff, patients and materials enter the surgical unit), transition zone (where staff put on surgical attire), semi restricted area (a peripheral area of surgical unit and includes preoperative and recovery rooms, storage space for sterile items, and corridors leading to the restricted area) and restricted area (consists of the operating room and scrub sinks).

Environmental controls and use of surgical attire increase as one move from unrestricted to restricted area. Staff with respiratory or skin infection and uncovered open sores should not be allowed to work in the surgical unit.

Unrestricted area needs no special traffic flow, whereas transition zone should allow only the authorized staff (Staff who perform or assist procedures in the procedure rooms). Displaying a signboard in local language limiting the entry of unauthorized persons may work in some facilities.

SEMIRESTRICTED AREA

- Limit traffic to authorized staff and patients at all times

- Have a work area for processing of clean instruments
- Have storage space for clean and sterile with enclosed shelves
- Have door limiting access to the restricted area of the surgical units
- Staff who work in this area should wear surgical attire and a cap

RESTRICTED AREA

- Limit traffic to authorized staff (staff who perform and assist procedures) and patients at all times
- Keep the door closed at all times, except during movement of staff, patients, supplies and equipment
- Scrubbed staff must wear full surgical attire and cover head and facial hair with a cap and mask
- Staff should wear clean, closed shoes
- Masks are required when sterile supplies are opened and scrubbed staff are operating
- Patients entering the surgical unit should wear clean gowns or be covered with clean linen, and have hair covered

3.4 CONTEXTUAL REVIEW SUMMARY

According to the reviewed literatures, conditions of HAI in Ethiopia is very high and the attention given is not enough while the review on the guideline it manages to cover infection control strategies but it is more inclined to utilization of existing hospitals rather than design. Furthermore, the guideline is prepared more as a recommendation than requirement.

CHAPTER 4

METHODOLOGY

4.0.METHODOLOGY

4.1. INTRODUCTION

This section is organized in four topics. These topics are aimed to show the method of getting answers and evidences in the research process. The first topic discusses about a research design that is suitable for meeting the objective of the research while the second topic elaborates on how to go through the assessments on each research question. Then the third topic discuss about how, from where and what kind of data is collected while the fourth and final topic identifies the sampling process and size from each data source.

4.2. RESEARCH DESIGN

This research is a case study research which is based on explanatory study. According to Robert K. Yin (1994), Explanatory study Search for theoretical propositions that can be elaborated to cover study questions, propositions, units of analysis, data-proposition links and criteria of interpretation through reviewing literature, discussing with investigators, asking challenging questions, thinking what is to be learned from the study. The goal of this research is to assess the existence of HAI, investigate its relation to architectural design flaws and implement a patient flow based design approach to minimize the risk on selected case study trauma hospitals.

Based on the definition of explanatory study an attempt to answer the research questions is formulated in three strategies.

1. To examine current literature from varieties of documents and guidelines on the existence of HAI, emergency hospital components, planning, lay outing and traffic flow strategies that should be incorporated to minimize risk of infection in accident and trauma hospital setting.
2. Identify the strength of the relation of the problem with architectural design through interview with medical and architectural design professionals and professional
3. Assessing selected case studies based on standards and medical and design professionals opinion in order to come up with gap identification and recommendation for evidence based design.
4. Using professional questionnaire assess the workability of the recommended design approach.

4.3. RESEARCH STRATEGY

This research is focused on two case studies presented. The case studies involve patient flow as the main focus of study along with unit layout, other traffic flows within the unit and IPC considerations.

The study will involve Aabet Hospital and Alert hospital with both being recently started, comparable sizes, minimum interrupting traffic within the compound, located in Addis Ababa, public hospitals and gives accident and trauma service.

The research methodology will employ three approaches

1. Finding out the existing situation
    a. Establishing the condition of the hospitals based on planning layout and patient flow
    b. Reviewing the condition and assess its impact on the risk of infection
2. Find out improvement strategies
    a. Identify architectural strategies to improve the existing risk.
3. Making recommendations
    a. This is after a careful study of the cases based on the literatures referred, appropriate recommendations will be made. These recommendations will offer design strategies that can be used when employing patient flow based design approach to improve condition of HAI.

4.4. DATA COLLECTION METHOD

Data collection is done through interview, visual inspection and professional assessment methods.

The researcher targeted to collect the following data from ministry of health

- Data related to the status of HAI, frequency of trauma cases, number of trauma hospitals in Addis Ababa.
- Relation between architectural design and infection risk in hospital premises
- The role of the ministry to monitor and control facility design and documents related to facility design and infection control strategies during facility design
- Assessment of patient flow based design approach to improve infection control

The researcher targeted to collect the following data from World health organization

- Data related to the status of HAI
- Relation between architectural design and infection risk in hospital premises
- Strategies employed (initiated) by the organization to improve facility design for better infection prevention and control.
- Documents related to infection safety strategy during designing hospitals

The researcher targeted to collect the following data from action areas (selected Case Hospitals)

- Data related to the status of HAI
- Hospital Practices to improve the status of HAI
- Unit based identification of Positive and negative points of the facility design for infection control
- General observation and collection of as built plan layout data and traffic flows within the hospitals is done

The researcher targeted to collect the following data from design professionals

- Unit based identification of positive and negative points of the facility design for infection control through critical and careful observation of as built drawings provided by the researcher.
- Recommendations Based on experience and existing standards to reduce infection risks

Assessment of patient flow based design approach to improve infection

4.5. SAMPLING DESIGN

Sampling for data collection is carried out through assessing the responsible facilities, institutions and personnel related to infection prevention and control in accident and trauma setting. These institutions are categorized in three as policy makers/ executers (Government body), NGOs, main action areas (Hospitals) and professional opinion.

Policy makers/ executers (Government body)

Therefore, EFDR ministry of health is selected under the category of policy makers. In this institution three experts from three units (directorates) are selected for interview based on the goal of the research. These unites are

- Emergency directorate
- Medical service directorate
- Planning, design and construction directorate

Non- Governmental organization (NGO)

WHO is taken as a potential organization for it works closely with MoH on the matter of IPC with professional assistance and also with financing IPC projects. An expert from IPC department is selected for interview.

Main case study areas (hospitals)

Accident and trauma hospitals are selected for their high risk of HAI due to patient's condition to aggravate the situation and also due to the higher degree of attention it needs because of venerable patients. Addis Ababa is selected as a setting for study as facilities dedicated to accident and trauma are found and also accidents related to road traffic and others are more prevalent in the city than anywhere else in the country. Dedicated accident and trauma services in Addis Ababa are given in three hospitals. Which are:

- Aabet Hospital
- Alert Hospital
- Black Lion Hospital

Two out of three is sampled as cases for study which are Aabet Hospital and Alert Hospital. These hospitals are selected with due consideration to their capacity, establishment time, being stand alone trauma centers and traffic volume within the compound.

Health care professionals

- At least one professional interview from each unit is made and Opinions related to the hospitals they work in, strength and weakness of the facility in giving the opportunity to control infection and improvements that can be an input for evidence based design is collected.

Health care building design professionals

- Selection of healthcare building professional was done in a serious of steps.
  - First informal communication with random people who are close to and inside the architectural design industry is done to identify which firms are recently involved in designing a notable hospital project
  - Then about ten firms are contacted based on the suggestions. Out of these, six are selected due to their involvement in more than one public hospital project in order to make the assessments more strong

- Project tem leaders are then contacted and given similar as-built plans with general overviews.
- Finally they are asked to assess the case hospitals based on their knowledge, experience and standard requirement for different aspect of hospital design in relation to patient safety.

4.6. METHODOLOGY SUMMARY

This chapter identified a kind of assessment through the research due to the nature of research objective, formulate a strategy on how to proceed through each research question, identify data sources and collect it from appropriate sample type and size.

As a result, qualitative research is selected due to the nature of the research objective and case study is chosen as a means through the research. Then based on the research question and strategy, data collection methods are decided to be through interview, policy review and observation of selected case studies.

Furthermore, two case study hospitals are selected with comparable parameters suitable for studying then collect data through observation and make more than two professional assessments on each of them with qualified professional.

Finally, three interview size from different units of MoH and case hospitals and one from WHO are selected based on their proximity to the research topic.

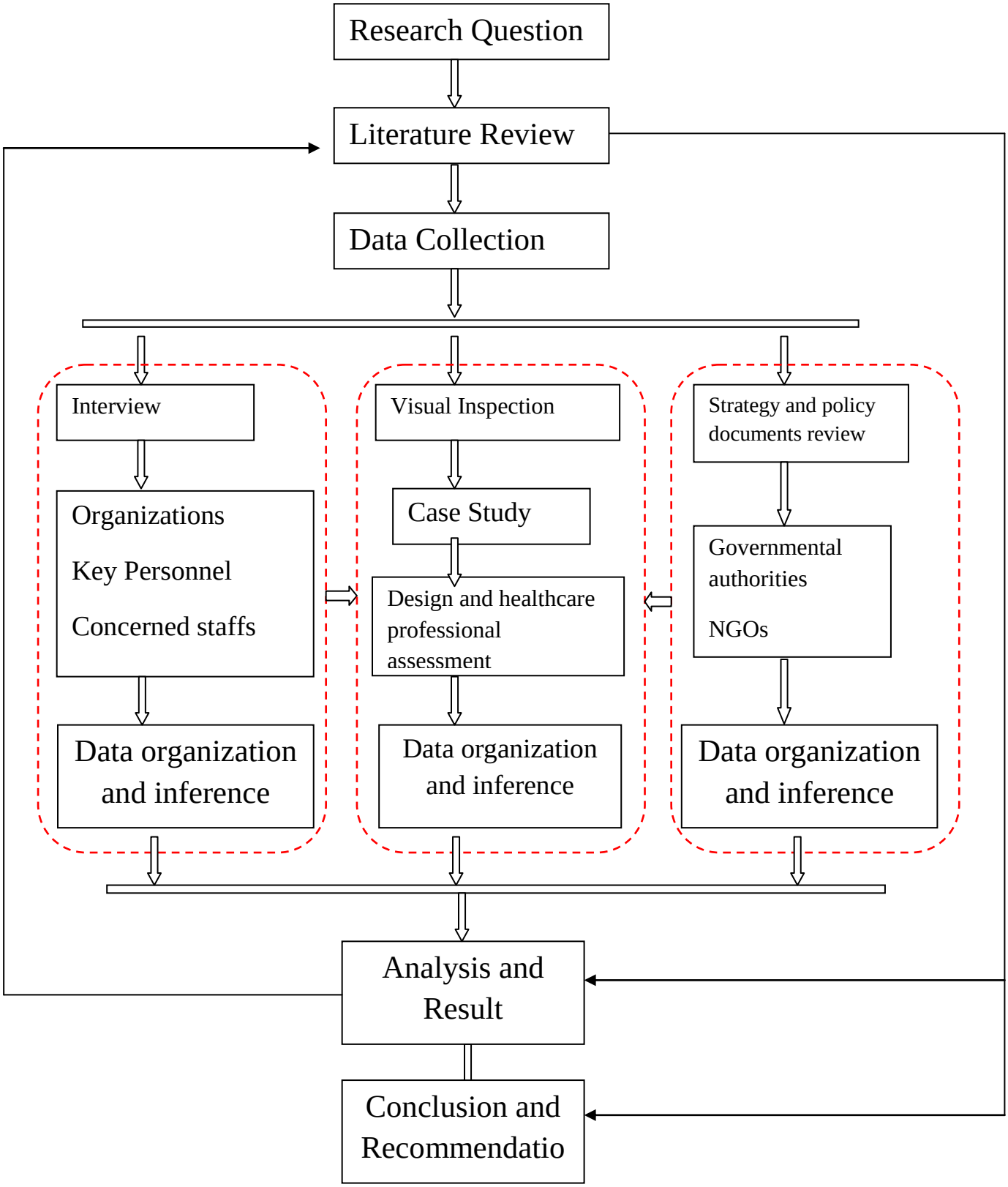


Fig: 1. Research Design diagram

CHAPTER 5

DATA PRESENTATION AND SYNTHESIS OF FINDINGS

5.1. INTRODUCTION

On this chapter, collected data is presented in order of research question for each interview and case study assessment is presented on a table format with a conclusion for each assessment. Then the presented data is summarized and analyzed through table synthesis system to reach to the findings.

5.2. DATA PRESENTATION

Data was collected through interview, visual inspection and professional assessment of cases as mentioned in the methodology section from the systematically selected groups of key personnel from the concerned institution.

At the ministry of health, three professionals from three directorates were interviewed. These directorates were selected based on their core task relation with the researches main theme. The directorates are:

- Emergency Directorate
- Medical service directorate
- Planning and construction directorate

One professional interview is taken as a primary data source from each directorate and each are asked similar sets of questions except a few specifically designed questions which relates to their specific task.

For emergency directorate, the questions are oriented more on current situation of the emergency and trauma hospitals related to their accommodation, operation requirement and safety measures on for IPC. Then finally their involvement also questioned on design and construction stage of hospitals as a government body.

The interviewee replied to each question to the knowledge of the directorate as:

> The local status of HAI in Ethiopian hospitals as a whole is unknown. Preparing a record format and distribution was done but implementation became difficult because of various issues. One of it can be a facility setup issue where IPC personnel can work around. As to accommodation, operation requirement and safety measures for IPC, they have developed a manual together with planning and construction department on general and specific scale which the researcher took it as a secondary data source on which can be used a tool to assess the design situation of the hospitals under study. The manual is also under revision to consider a wider scope and current situations. Finally as government body, the directorate have no mandate to question or involve on

planning and construction of emergency settings not even assessing the IPC safety measures after construction and making approvals.

In the medical service directorate, they have a division working on IPC. An expert from this division is asked questions like the status of medical services on emergency and trauma hospitals, what is the status and how can they respond to the risk of infection in those settings, what is their involvement in traffic control as medical service IPC experts and what their role is in planning and construction of hospitals as a government body.

The interviewee replied to each question to the knowledge of the department as:

> Medical service in Ethiopia is sub- standard even for current economical status of the country. Every facility is overcrowded in facility level with a low number of health professionals per unit per patient to make it worse. They have difficulty doing surveillance and identifying HAI and also setting up functional IPC on hospitals due to various reasons but one reason could be facility setup and the over crowdedness. To respond to the risks, they have prepared a manual called infection prevention and patient safety which includes traffic flow and activity pattern as one of the topics. This topic will be used later on to assess the hospitals under study. As to their involvement in planning and design stage, they have no legal background to involve in such stages and make decision.

Form planning and construction directorate a senior architect is selected for interview. The questions for interview are more related to facility design and IPC precautions while designing and more specifically on the relationship between activity pattern, traffic management and IPC in emergency setting and their influence on planning and construction of hospitals in the country.

The interviewee replied to each question to the knowledge of the department as:

> The directorate's primary task in the ministry is designing and constructing hospitals and health centers in different parts of the country and then preparing and revising standards and facility design guidelines is other one. These two tasks require collaborating with different directorates in ministry for more accurate and solid output. When designing new projects, preparing and revising guidelines IPC is one of the major issues to consider. On the current guideline also there is a section for infection prevention and patient flow but it's not categorized and related to the facility service standards. While designing a number of strategies can be used to minimize the spread of infection which the following can be some of it:

- Proper layout of the programs
- Traffic control and management
- Material specification
- Water supply and sanitation

Out of the strategies, traffic control and management is primarily related to airborne infection control then physical contact. Therefore for emergency setting especially for countries like Ethiopia, where overcrowding is common, designing for traffic control as a strategy for IPC can be a good way.

When it comes to controlling design and construction of new hospitals, and modification of existing ones, they have no legal way to monitor and control if they are going according to the guidelines. After construction, there is a regulatory body that will assess and provide a license for a facility but the criteria's and requirements can't do much on general setup of the facility.

The other institution under the list of data collection is WHO. This institution is doing assessment and IPC program on local level. The researcher interviewed the focal person in the institution with questions related to the status of HAI in Ethiopia, what are the activities the institution doing related to IPC and facility design, with whom they are working with and what do they expect from their program.

The interviewee replied to each question to the knowledge of the program as:

WHO addresses IPC as a major issue worldwide as average 10% of people who visited a hospital will go back home with at least one HAI. This number varies based on the facility setting and development level of the country under question but still doesn't get less than 5%. As to the condition in Ethiopia, despite the efforts made by the WHO local program on IPC to work on surveying the level of HAI, it is still not successful to estimate the figure.

IPC national implementation program in WHO has 8 (eight) core components. Each of which has a relevant impact on the attempt to eradicate HAI. The components are:

- IPC programs
- Evidence based guidelines
- Education and training
- HAI surveillance
- Multimodal strategies
- Monitoring and audit of IPC practices and feedback

- Workload, staffing and bed occupancy (facility level)
- Built environment, material and equipment of IPC (facility level)

Out of these eight the last four are more related to the study theme. Based on the interviewee, hospitals in Ethiopia lack infection audit not only because the lack of surveillance system but also because of the heath care setup (planning). The other issue the informant raised was the material and equipment selection and placement during planning and construction stage. This has resulted in difficulties on implementing infection prevention and control protocols while giving medical services.

5.3. CASE STUDY

5.3.1. PATIENT FLOW ASSESMENT

CASE 1- AABET HOSPITAL

OVERVIEW

Aabet hospital is located on the left side of the street that goes from Yohannis church around piazza to Merkato, Gojam Berenda, Addis Ababa. It has a site area of 5600m2 with 2B+G+4 building on 1800m2 built-up area. It was initially designed as a hotel building but later it was changed to a general hospital design then st. paul hospital MMC rented and repurposed it as accident, burn, and trauma hospital.

The hospital is governmentally owned hospital which is available for any accident, trauma, burn and other emergency cases on direct or referral admission.

The hospital receives from (15) fifteen to (35) thirty five new trauma cases each day.

General positive points of the hospital:

1. Built away from a noisy road and also on the lower part of the topography of the site which further improves the acoustic quality of the hospital
2. The site has two compound entrances which the hospital management took advantage of to improve the emergency traffic management system.

General negative points of the hospital:

1. small and poorly ventilated lobby
2. Poor location of vertical circulation
3. Poor grid spanning
4. Very few parking space for personal vehicles with emergency

Fig: 5. AaBET hospital external picture

Patient flow data presentation

Patient flow data at Aabet hospital is collected through visual inspection and communication with triage personnel. Arriving patients are observed for their care transition and a chart from triage personnel is analyzed to map the most frequent patient care paths within the hospital.

Therefore the identified major patient care paths are:

1. ED Arrival, Resuscitation, OR, Inpatient, Discharge
2. ED Arrival, Triage, OR, Inpatient, Discharge
3. ED Arrival, Triage, ED observation, Discharge
4. ED Arrival, Triage, ED observation, OR, ICU, Inpatient, Discharge
5. ED Arrival, Triage, ED observation, ED procedure, Discharge

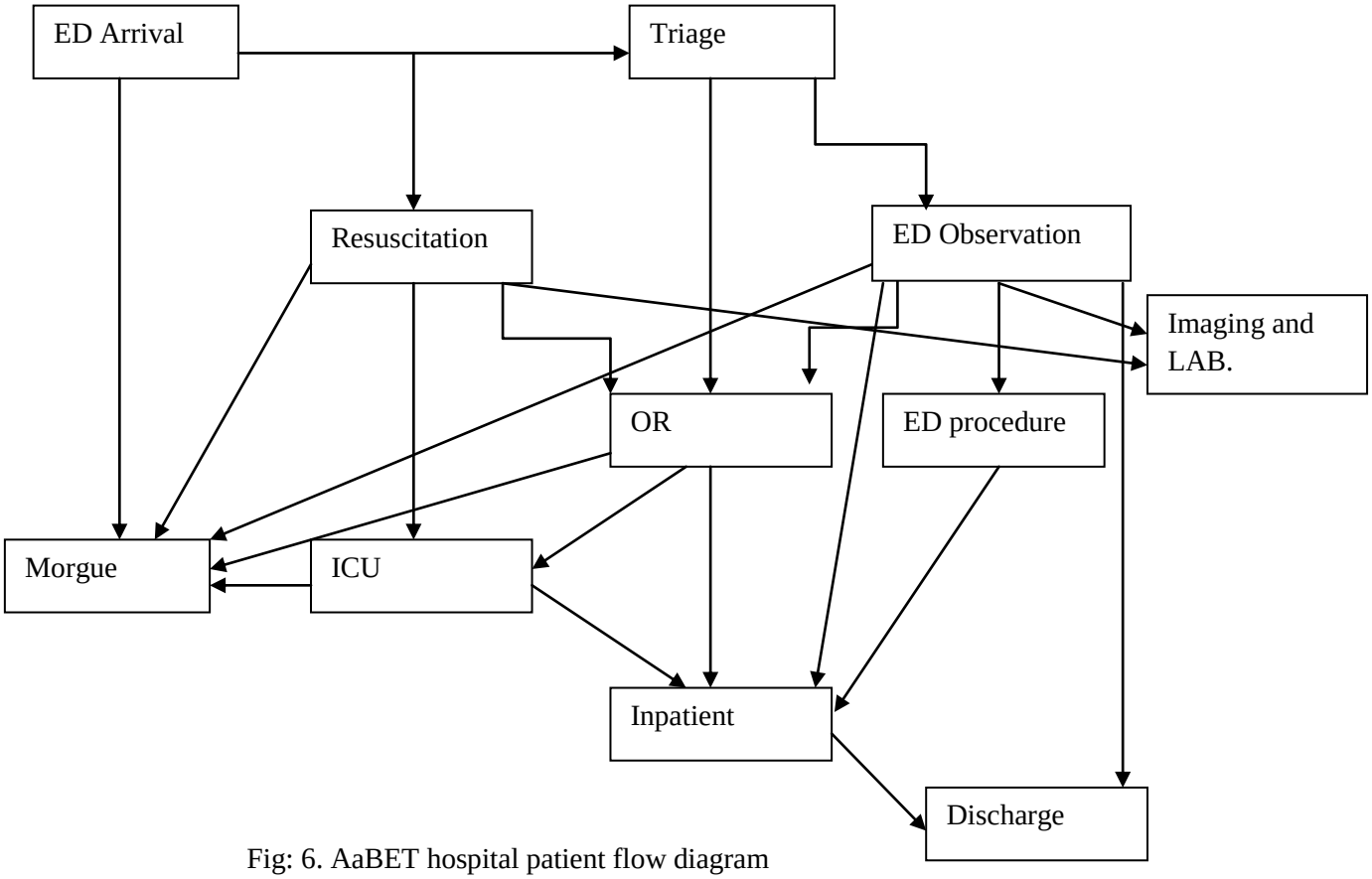


Fig: 6. AaBET hospital patient flow diagram

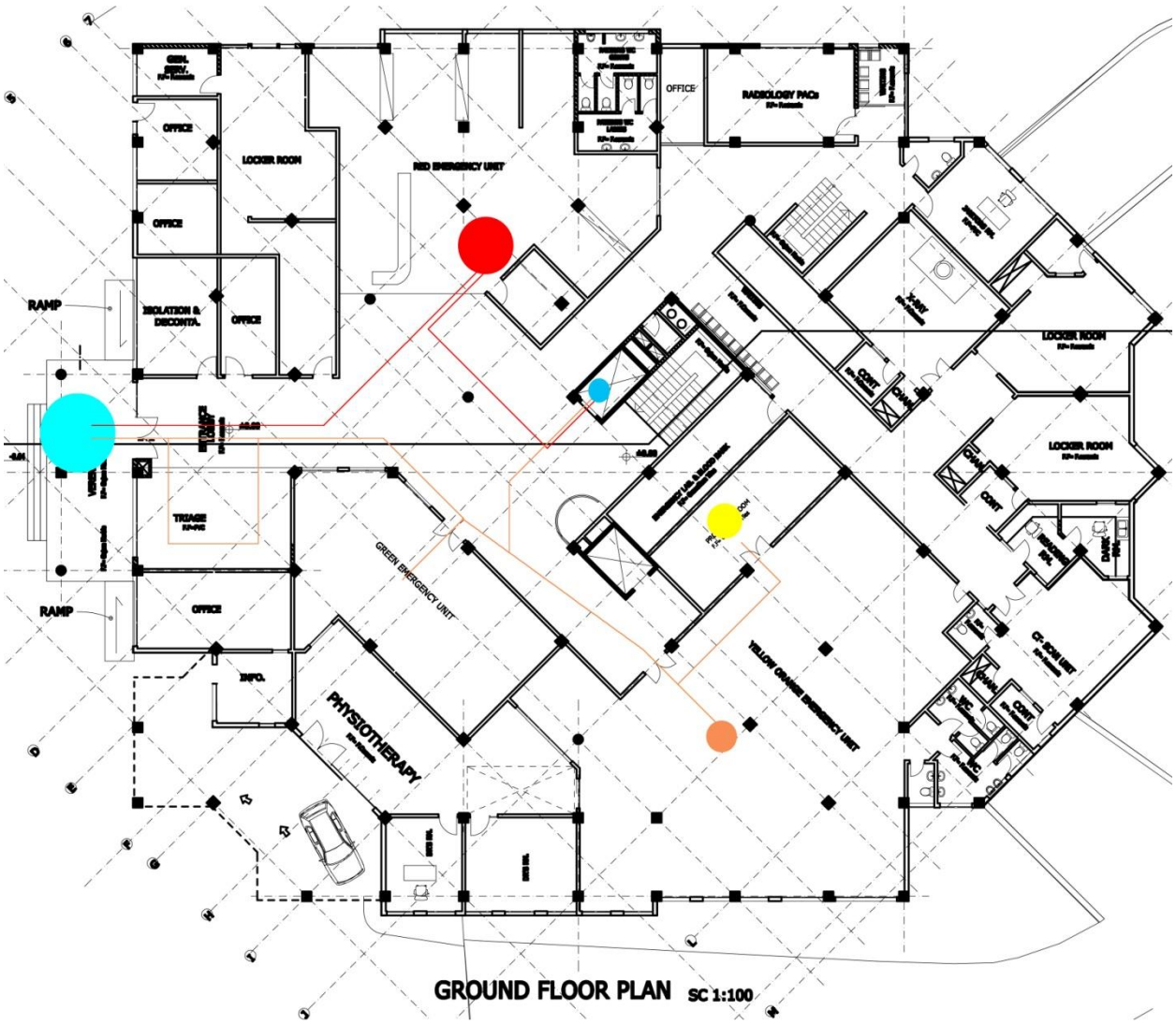


Fig: 7. AaBET hospital major patient flow paths

Table 1. DESIGN PROFESSIONALS ASSESSMENT OF CASE STUDY

CASE STUDY OBSERVATION FROM THE HOSPITAL

General

Consultant (General Hospital)- GATEMeTS INTERNATIONAL PLC
CLIENT(General Hospital)- Ato TIBEBU
Revision consultant- UNKNOWN
Revision client- St PAUL HMMC
Site area- 5600sqm

Observation on ground floor plan

The exam/ treatment areas are on right and left side of the entrance after the triage. The left side being a resuscitation area, the rite sides are yellow green and orange exam/ treatment areas. Straight through the entrance and past the resuscitation area vertical circulation is situated giving a visual barrier to the medical imaging area behind it.

One minor procedure room is located which is directly accessed from the yellow Exam/ treatment area.

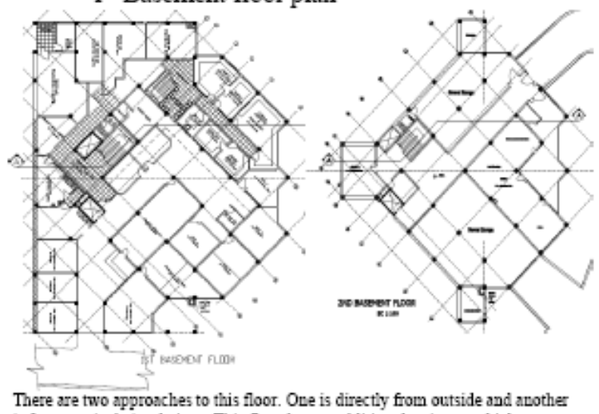
Two bathrooms with male and female sections are located inside the red (resuscitation) and yellow sections of the exam/ treatment areas.

Physiotherapy , emergency laboratory, Isolation/ decontamination and some staff accommodations are also located on this level of the hospital.

Observation on first floor plan

Patients arrive at this floor through either of the two elevators or the staircase. This floor contains two units. The surgical and burn unit. Hydrotherapy is also included in the burn unit. The surgical unit has taken much of the floors space. It originally was designed with two OR rooms but now it has four ORs. This has significantly changed the patient and other traffic flows within the unit. One of the elevators opens at the restricted area within the surgical unit.

1st Basement floor plan



There are two approaches to this floor. One is directly from outside and another is from vertical circulations. This floor has an additional staircase which connects it to ground floor.

This floor mainly contains two units. OPD with one procedure room and central laboratory. It also contains medical and administrative staff offices, medical record and central pharmacy.

PROFESSIONAL ASSESSMENT OF THE FACILITY DESIGN

CONCLUSION

Patients at each process through the medical service should better be contained and monitored to control infection. Spaces such as the resuscitation area and orange exam/ treatment space needs to be controlled.

Surgical unit needs to be redesigned with proper channel for all the traffic flows and should include all the necessary supply storages.

First Basement floor has a proportionally higher load and patient traffic to this floor needs to be shared to other floors.

In summary the hospital has proper accommodation but poor arrangements of facilities and poor channeling of different traffics necessary for healing process. Therefore, redesigning it with better caution for this parameters will have a potential to improve services in the hospital.

- isolation right after the emergency door is ideal place with minor appropriation

-small space in between to serve as both circulation and attendant waiting.

-Good location of resuscitation for critical patient but its exposed to public and prone to infection

- Yellow- green and orange exam/ treatment spaces are no more than corridors

- Minor procedure is found only within orange area which is too far away for much number of patients and too much workload in one place.

-treatment spaces, equipment supplies, dirty and clean spaces etc area are not properly designated.

-Provision of medical service spaces are better taught of than patients travel through the treatment process as patients travel back and fourth and cross unnecessary paths for diagnostic imaging, laboratory and procedure.

-Traffic flow through the elevator which opens up in restricted area is unacceptable.

-Patient flow at the surgical unit should be rechecked at the preparation, anesthesia.

-Staff and clean supply access to the OR interferes with the leaving contaminated equipment path which can be a major issue of contamination.

-Burn unit could more suitable on ground floor.

-Staff accommodation are placed on either sides of the OR which staff needs to cross restricted zones for unnecessary reasons.

-At first basement OPD, central laboratory , minor procedure and central pharmacy are units with much visits from patients and attendants. Therefore to better handle patient load some function better to be moved to other floors and waiting areas better to be moved to outer wall for better ventilation.

-the current layout doesn't allow for proper travel of patient through the treatment process as every service shares the same central corridor.

As a trauma center, emergency lab and blood bank are given low consideration.

Table 2. DESIGN PROFESSIONALS B ASSESSMENT OF CASE STUDY

CASE STUDY OBSERVATION FROM THE HOSPITAL

General

Consultant (General Hospital)- GATEMeTS INTERNATIONAL PLC

CLIENT(General Hospital)- Ato TIBEBU

Revision consultant- UNKNOWN

Revision client- St PAUL HMMC

Site area- 5600sqm

Observation on ground floor plan

The exam/ treatment areas are on right and left side of the entrance after the triage. The left side being a resuscitation area, the rite sides are yellow green and orange exam/ treatment areas. Straight through the entrance and past the resuscitation area vertical circulation is situated giving a visual barrier to the medical imaging area behind it.

One minor procedure room is located which is directly accessed from the yellow Exam/ treatment area.

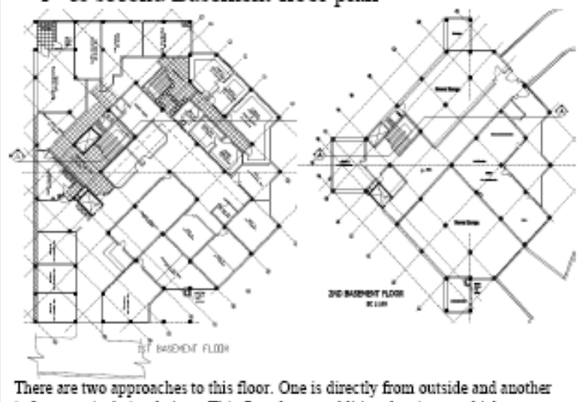
Two bathrooms with male and female sections are located inside the red (resuscitation) and yellow sections of the exam/ treatment areas.

Physiotherapy , emergency laboratory, Isolation/ decontamination and some staff accommodations are also located on this level of the hospital.

Observation on first floor plan

Patients arrive at this floor through either of the two elevators or the staircase. This floor contains two units. The surgical and burn unit. Hydrotherapy is also included in the burn unit. The surgical unit has taken much of the floors space. It originally was designed with two OR rooms but now it has four ORs. This has significantly changed the patient and other traffic flows within the unit. One of the elevators opens at the restricted area within the surgical unit.

1st & second Basement floor plan



There are two approaches to this floor. One is directly from outside and another is from vertical circulations. This floor has an additional staircase which connects it to ground floor.

This floor mainly contains two units. OPD with one procedure room and central laboratory. It also contains medical and administrative staff offices, medical record and central pharmacy.

PROFESSIONAL ASSESSMENT OF THE FACILITY DESIGN

CONCLUSION

Emergency medical service area should be redesigned for better patient handling and control of infection following appropriate guidelines and prioritizing functions vital for the process than secondary functions like rehabilitation. Furthermore, facilities related to infection control like bathroom, hand wash etc should be placed with proper spacing.

First floor has a potential to be housed by surgical department with appropriate traffic flow including equipment processing and ICU.

Services on the first basement should be shared to other floors to ease the stress of too much patient flow.

In conclusion the hospital has almost all appropriate services needs further adjustments for proper service flow and patient safety.

-Exam/ treatment spaces are uncontrolled big spaces and has much more number of patients than recommended by standards.

-Physiotherapy on the ground floor takes an important space for a less urgent function.

-Patient paths while getting treatment specially, from triage to orange Exam/ treatment to OR and diagnostic imaging is long and full of crossings.

-Bathroom and hand washing provisions are insufficient.

-Medical imaging unit has to be proportional to the incoming patient flow to avoid delays.

-Isolation being much closer and opening directly to the main corridor increases its risk of spreading infection into the inner rooms.

-Proper staff changing and accommodation at proper places needs to be provided.

-As a trauma center, emergency lab and blood bank are given low consideration.

- Traffic flows from an elevator inside the restricted area should be avoided.

-Surgical ICU needs to be adjacent to the OR as trauma center is much likely to be visited by critical patients.

-The layout of surgical unit demands more consideration in placing order of restriction as it passes from public area to core surgical theatres.

-Functions like supplies for pharmacy, clean linen etc seems to be omitted.

-The OR room sizes are slightly lower than demanded on the standard with multiple trauma patients.

-Staff passes through a dirty equipment decontamination area before accessing the restricted corridor which OR rooms are directly accessed from.

-Clean supply travels long distance from basement through public vertical circulation and stored to clean supply storage. It passes through the decontamination area twice before reaching the OR.

-Waiting area at first basement is located in the middle of service units and away from natural ventilation which is a big risk of airborne contamination.

-The services on the first basement are too much and attracts too many traffic and increases risk for infection transmission.

-CSSD on the second basement could have been effective if it was on the same floor with the surgical department. This floor can also share the burden of first basement floor.

HEALTH-CARE PROFESSIONALS' ASSESSMENT OF CASE STUDY

In Aabet hospital the researcher used all data collection methods that are mentioned in the methodology section. One professional from each department that are related to the theme of the research are selected. In total five interviews are made from quality assurance, surgical department, CSSD, central laboratory and emergency care unit. Initially the researcher had a plan to interview the IPC officer in the hospital. But IPC is not established as a department yet and currently, the quality assurance department is responsible for the IPC tasks.

All the interviewees asked the same interview questions which are related to the status, cause and rate of infection, impact of traffic flow on IPC, the problems they see in the facility or working environment that might be contributing to infection etc.

> At the emergency care unit, since there is no surveillance system, it's difficult to tell the status of and rate of infection. But as a professional, the interviewee said, it can be told that there is a considerable rate and risk of infection as there are lots of situations in the unit that can increase the risk. As an example the crowded lobby, not only with attendants but also patients who are taking primary and even secondary care laying on benches and floor is a big risk infection for the patient and others around. The flow from the triage is classified into green, orange and red areas. The red area is to treat patient with extremely life threatening condition. This area is immediately after the triage but open to the lobby. It can even be considered as the lobby itself. At this place minor procedures are also undertaken. The orange area is where the majority of the patients are admitted to. This area treats patients with emergency cases which has less critical condition to the red ones. This place runs with a room full of patients on bed and floor on only one procedure room. There is a large number of waiting patients on the procedure room waiting area, which is also treatment and recovery area, for their turn to get treatment.
>
> Proper traffic flow and management is one of the factors that are increasing the risk of infection in the hospital. There is a little effort in segregating different traffics but the hospital layout itself is not suitable to do more. Currently lots of security guards are trying to filter authorized and non authorized personnel in and out of different units. Furthermore, at the main emergency patient entrance, security guards make sure it is not being used as exit by any traffic. This keeps the entrance free of obstruction for incoming emergency patient. But other places are almost impossible to control even when attempting, it results in more crowd and chaos than improving it. Program wise there is a gap on provision especially spaces that are demand to establish proper IPC such as isolation room. Even though there is a space marked as isolation area, it is currently

used to decontaminate ‘poisoning’ emergency and placement wise it is placed to be opened directly to the lobby but still without any air or physical flow control.

As a recommendation, the emergency unit staff believes primarily, the status of patients flowing to the hospital puts too much burden for the hospital as a whole. They are treating much more than the facility and the staff within it can support. The only way to do this is building other emergency facilities on other sites. Then when the optimum amount of patient is flowing, improving the layout of the hospital through including the important missing functions can bring a better setting for the service as a whole.

In the quality assurance office, professionals believe the hospital is in a poor condition as it was not initially designed for emergency hospital purpose but a hotel then the layout is changed to general hospital. Then st. Paul HMMC rented it for burn, emergency and trauma hospital with a little improvement to the general hospital layout. The office tries to do different improvement strategies time to time to improve the service efficiency and quality. One of the cases the office has been doing was studying the patient flow from the perspective of service efficiency. It studied how to identify sort and flow the patients from unit to another and identifying the delays and causes of them. The result of the study was a map of patient flow with service benchmarks and points of delay. This is used to efficiently flow the patient traffic and sort out a way to minimize delay and overcrowding through dealing with the causes of delay. The office is also trying to establish IPC team which can work on IPC issues in the hospital. This team will work on infection surveillance systems, causes of infection including traffic flow and minimizing mechanisms.

As a recommendation, solving issue of overcrowding is a main concern then improving layouts comes second along with material finishing and air flow systems.

In central laboratory, the laboratory itself is a bit away from the public. This could have given it advantage of minimizing contaminants to and from it. But it has a sample collection area within the lab where sample processing is done. Proper ventilation system and sample collection and transportation system are identified by the interviewee as risk for infection transmission. Sample collected from emergency, burn and inpatient areas will be transported to the central lab with no proper path, procedure and handling mechanism. Furthermore, the laboratory is so small for the current demand and some tests including most of microbiology related tests are being sent to other hospitals.

As a recommendation, linking and proper channeling of sample collection stations to the central lab, improving the ventilation and planning can improve the IPC.

The surgical unit is a part of hospitals where traffic flow management significantly makes a difference. Two interviews were made from this unit one of which is focused on the inside of operation theatre and the other one is focused on the whole components and traffic flow of the system.

The surgeons inside the operating theater have a lot basic things to ask.

- To start with the OR floor is finished with porcelain tile with considerable amount of broken tiles.
- The wall is a gypsum plaster and non water resistant paint finish.
- The AC system, on top of not functioning properly, it is installed with the whole duct system exposed to the inside of the OR.
- The OR lump produces large amount of heat resulting in sweating and uncomfortable working environment for the crew.
- The wall enclosing the OR has top windows on which lots of dust particles are accumulated on the neglected window sill.
- Directly accessed from the inside the OR there are a clean equipment supply and dirty equipment storage spaces which are not currently functioning due to the current improper traffic flow within the surgical department.

With all this issues within the inside of the OR, the whole surgical unit traffic flow situation is also a big trait to IPC. According to the interviewee, the designed patient flow system is impossible to manage because of lots of unnecessary access which cannot be controlled. Furthermore, the number of ORs for the whole hospital was not enough and they had to do their own adjustments to get additional two ORs.

The other factor is the vertical circulation. The elevator that is serving to bring patients to the surgical unit is being used by everyone. With this the case, the elevator opens in restricted area of the surgical unit and it makes it hard to regulate unnecessary traffic from this area.

Regarding dirty and sterile equipment flow, the flow line uses the same corridor, cart and personnel. The only segregation attempt is through packing them with linen.

Staff flow is also similarly not regulated due to the lack of space functional programs are overlapped and placed on unnecessary side which makes the situation worse.

Recommendations from both interviews are focused on design aspect. The first one being appropriate material finishing and construction system, the second one is inclined to the planning, lay outing and traffic control.

CASE 2- ALERT HOSPITAL

OVERVIEW

Alert trauma center is located within a big compound of hospital- research center complex. The complex itself is located on the west side of Addis Ababa, around 'Zenebe work', along the ring road from Tor-Hayloch to Ayer-Tena. The complex has 324000m2 site area in which different centers are established in. One of those centers is the Trauma center.

Although Alert hospital and research center complex is established around 60s, the trauma center is established not more than five years ago. It is initially built for administration building purpose but later it was redesigned as trauma center by ministry of health professionals.

Fig: 8. Alert Hospital external picture

The hospital receives from 5 (five) to 20 (twenty) new trauma cases each day.

General positive points of the hospital

1. Enough parking spaces for ambulance and private cars.
2. Close to the main gate relative to other facilities within the compound
3. Situated in a medical compound with possibilities of referrals when necessary.
4. The compound is full of trees which is a source of good breeze.

General negative points of the hospital

1. Poor consideration for waiting area regarding placement and relationship to other clinical spaces.

The hospital is a G+1 building on 1000m2 built-up area designed with L-shape layout having a public approach at the center. Initially the central linkage point is taught to be the main entrance and public area which takes to both wings and upstairs. But after being redesigned to trauma hospital, the access is changed to one of the wings which is closer to the main gate of the compound. The attendant waiting kept at the verandah.

Patient flow data presentation

Patient flow data at Alert hospital is collected through visual inspection and communication with triage personnel. Arriving patients are observed for their care transition and a chart from triage personnel is analyzed to map the most frequent patient care paths within the hospital.

Therefore the identified major patient care paths are:

1. ED Arrival, Triage, Resuscitation, OR, Inpatient, Discharge
2. ED Arrival, Triage, OR, Inpatient, Discharge
3. ED Arrival, Triage, ED observation, Discharge
4. ED Arrival, Triage, ED observation, OR, ICU, Inpatient, Discharge
5. ED Arrival, Triage, ED observation, ED procedure, Discharge

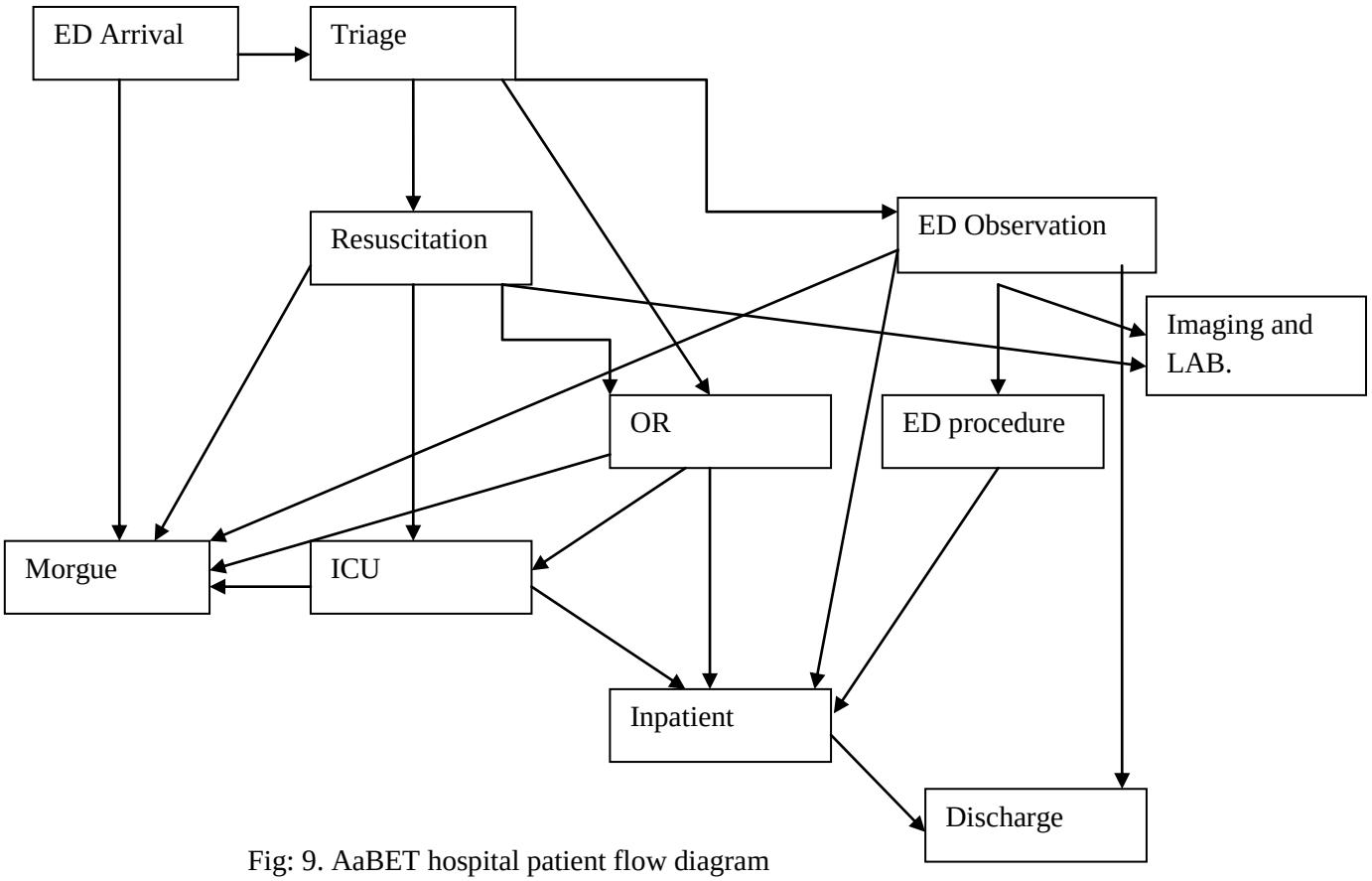


Fig: 9. AaBET hospital patient flow diagram

Fig: 10. Alert Hospital major patient path

HEALTH-CARE PROFESSIONAL ASSESSMENT

In Alert hospital the researcher used all data collection methods that are mentioned in the methodology section. One professional from each department that are related to the theme of the research are selected. In total five interviews are made from surgical department, CSSD, central laboratory and emergency care unit. Initially the researcher had a plan to interview the IPC officer in the hospital.

All the interviewees asked the same interview questions which are related to the status, cause and rate of infection, impact of traffic flow on IPC, the problems they see in the facility or working environment that might be contributing to infection and recommendation on improvements.

At emergency care unit one professional interview is made and the interviewee responded to the questions as follows:

The hospital is initially designed for administration purpose and later changed to trauma center by MoH design professionals. Due to this fact the hospital has minimum considerations in every aspect which resulted in HAI susceptible situation in the setting. Even though the hospital doesn't have infection tracking system, infection is common and the design of the facility contributes significantly.

To identify specific areas that commonly contributes to the existing HAI as identified by the interviewee are:

- Entrance
- Triage
- Staircase
- Lack of isolation
- Overcrowding

Furthermore, patient segregations while admitting are not done properly at the triage because of lack of designated space. For example, burn cases are admitted similarly as other trauma cases while burn cases are much more infection sensitive compared to others.

As a recommendation, the interviewee suggested separate entrance and exist for incoming and leaving patient traffic, separate vertical circulation for patient, staff and equipment, controlling overflow of people through segregating the authorized and unauthorized personnel, improving air quality through natural and mechanical means, proper provision of staff facility, improving hand washing by providing proper hand wash stations.

Two professional interviews from surgical unit is taken and the interviewees replied as follows:

The surgical unit is totally out of standard and is as good as minor procedure units. Nothing in the unit is appropriate for the service that is being provided and the infection situation without question is high. Primarily the HAI situation is aggravated by the facility setting which doesn't provide the platform to perform standard IPC protocol. Furthermore, talking about specific problems in this setting is not possible as there is almost nothing right in the unit. But as a recommendation channeling of patients, staff access and preparation, equipment access and removal of dirty equipment and linen, clean supply access, segregation of clinical area, resting space for staff, access control for every traffic is recommended.

From diagnostic and medical imaging department the professional interview is conducted. Both professionals replied to the situation of HAI in the facility as a difficult matter to discuss without assessment but inevitable as it is common even in properly designed and managed facilities.

Design wise, the interviewees replied, the facility has many problems that improvement will not be enough to come up with a properly functioning hospital but to build another new hospital. Until then a few improvement can be done for a bit better service such as improving the patient waiting and flow to the laboratory and medical imaging, improving transportation of specimen, specimen collection location, improving patient transportation and overflow in medical imaging units, managing the contact scenarios while using the circulations within the building, segregation of patients and other traffic, improving facility hygiene are implied as starting point.

Table 3. DESIGN PROFESSIONALS A ASSESSMENT OF CASE STUDY ON ALERT HOSPITAL

CASE STUDY OBSERVATION FROM THE HOSPITAL

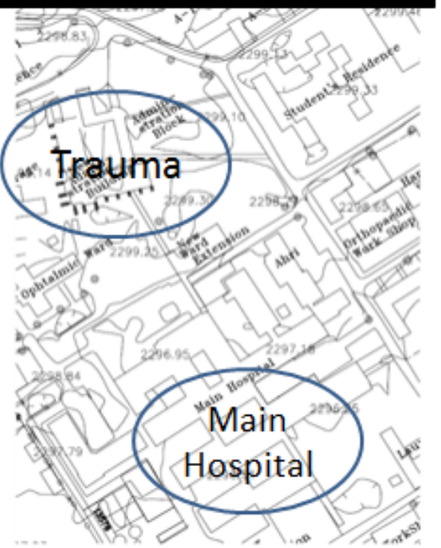
Consultant (Administration Building)- SKAPE CONSULT
CLIENT(Administration Building)- MoH, Alert Hospital
Revision consultant- MoH and Alert hospital staff
Revision client- Alert Hospital
Site area- 2250sqm with in 324000sqm hospital compound

The hospital has L-shape layout which one of the wings has an entrance for receiving patients and a corridor leads from the corner of one end of the wing to the other.

Patients arrive at this level and get triaged right after the entrance. This space also serves as a yellow green exam/ treatment space. Across a corridor from yellow – green, orange exam/treatment space is located. Along the corridor, isolation, procedure room, laboratory are there before getting to resuscitation area and the vertical circulation. After the vertical circulation, passing through a nursing unit medical imaging area (mainly CT-Scan) is found.

This floor contains three units which are surgical, ICU and nursing units. The surgical unit. The surgical unit was initially designed with two ORs but later changed to three. ICU is located on the other wing of the L-shape after the vertical circulation.

Nursing unit begins right after the surgical unit in front of the stair's lobby then comes the ICU to be followed by other nursing rooms.



The trauma center share some facilities with other centers and the main hospital within the compound.

PROFESSIONAL ASSESSMENT OF THE FACILITY DESIGN

CONCLUSION

The exam/ treatment area needs much improvement on patient flow management and provision of the necessary programs with proper layout.

It also needs better strategy to receive and process patients without congestion on the receiving area which also suggests for preferably horizontal or vertical expansion.

Surgical department demands a deeper space and trying to redesign with the current space will not present much different result.

Generally it will be better to build another structure than trying to improve the existing one.

The layout at admission level at alert hospital is a linear kind which takes a single corridor and arranges right and left.

There is no separate triage which doesn't allow isolation before joining other patients.

The entrance is very narrow and congested with patient and staff function.

Its long and narrow plan gives it a good opportunity for natural ventilation but the proportion of occupancy vs size of rooms looks risky.

Resuscitation is located far away from arrival which is not recommended by standards.

Provision of medical imaging and other diagnostic and treatment functions seems

Surgical unit on the first floor is hardly qualifies as surgical unit

ICU is located across a corridor which is not recommended by standards

Hand hygiene and other infection prevention facilities are hardly available on the nursing areas.

The trauma center looks far away from the main hospital to share facilities.

Table 4. DESIGN PROFESSIONALS A ASSESSMENT OF CASE STUDY ON ALERT HOSPITAL

CASE STUDY OBSERVATION FROM THE HOSPITAL

Alert trauma center is located within a big compound of hospital- research center complex. The complex itself is located on the west side of Addis Ababa, around 'Zenebe work', along the ring road from Tor-Havloch to Ayer-Tena. The complex has 324000m2 site area in which different centers are established in. One of those centers is the Trauma center.

Although Alert hospital and research center complex is established around 60s, the trauma center is established not more than five years ago. It is initially built for administration building purpose but lafer it was redesigned as trauma center by ministry of health professionals.

The hospital has L-shape layout which one of the wings has an entrance for receiving patients and a corridor leads from the corner of one end of the wing to the other.

Patients arrive at this level and get triaged right after the entrance. This space also serves as a yellow green exam/ treatment space. Across a corridor from yellow – green, orange exam/treatment space is located. Along the corridor, isolation, procedure room, laboratory are there before getting to resuscitation area and the vertical circulation. After the vertical circulation, passing through a nursing unit medical imaging area (mainly CT-Scan) is found.

This floor contains three units which are surgical, ICU and nursing units. The surgical unit. The surgical unit was initially designed with two ORs but later changed to three. ICU is located on the other wing of the L-shape after the vertical circulation.

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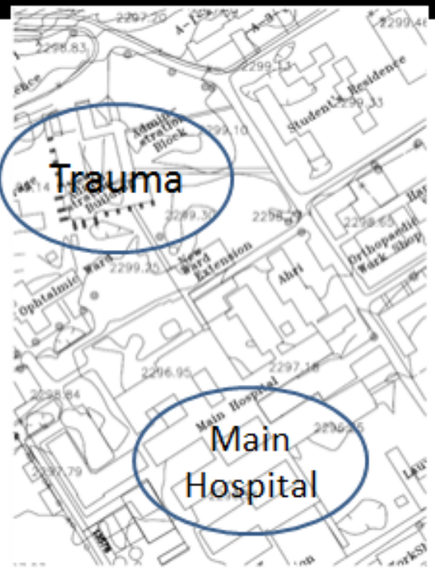


PROFESSIONAL ASSESSMENT OF THE FACILITY DESIGN

As the trauma center has wider spaces around for expansion, it can take advantage for expansion and provide appropriate size of accommodations for the necessary service. Furthermore, if surgical unit can be brought to ground floor and expand to the neighboring free space, it will have opportunities to be redesigned fulfilling the standard requirements for trauma surgical unit.

Therefore, based on trauma hospital design and considering all the shortcomings this center cant be properly improved unless all the structural system is changed.

-narrow corridor

- far resuscitation area

-No hand hygiene provision

-Improper isolation

-Inadequate functional program

-Only CT-scan is provided to serve as medical imaging unit

-Too narrow spaces provided for lab, pharmacy, procedure etc.

Surgical unit

-no segregation of clean and dirty functions

- all supplies and removals occur in one direction

- impossible to put restriction on unnecessary traffic

- two out of three OR rooms have sizes that can only serve as minor procedure

- doesn't have the necessary accommodation of trauma surgical unit

Being located inside a compound of a hospital complex it can take advantage of all the facilities inside with the exception of delays occurred due to sharing of common facilities and travel distances.

5.4. SYNTHESIS OF FINDINGS

5.4.1. POLICY MAKERS AND NGO ASSESSMENT AND SOLUTION IMPLICATION SUMMARY

Gap assessment and solution implication	
Gap assessment	Improvement implication
- No HAI data available - Little is done on following up implementation of HAI strategy - No authority of implementing the prepared IPC guidelines and strategies - Sub- standard medical facilities making implementation of IPC difficult - Prepared manual traffic management for infection control only checking for post occupancy situations - IPC guidelines are not categorized and related to facility service standards - Material and equipment selection and placement problems during planning, design and construction of healthcare facility. - Overcrowding	- Necessary strategies during design ▪ Proper layout of programs ▪ Traffic control and management ▪ Proper material specification ▪ Water supply and sanitation management - Traffic control and management to handle overcrowding - Design and construction follow up authority for healthcare facilities is essential - Appropriate placement of materials and equipments of IPC during design and construction stage. - IPC assessment manual for design stage needs to be prepared - IPC related spaces needs to be one of the basic requirements within a healthcare facility

Table 5. Policy makers and NGOs gap assessment and solution implication

5.4.2. CASE STUDY ASSESSMENT AND SOLUTION IMPLICATION SUMMARY

GAP ASSESSMENT SUMMARY

Medical professional gap ID					
Aabet ER	Alert ER	Aabet Diagnostic	Alert Diagnostic	Aabet procedure	Alert procedure
overcrowding	Minimum considerations	Sample collection and transportation	Patient waiting location	Floor and wall finish	Few standard consideration
Lack of segregation	Narrow entrance and triage area	Size of the lab	Patient flow direction and magnitude to the lab and imaging	Ventilation system	Everything is clustered around a single circulation
Lack of proper isolation	Poor triage location and distribution		Transportation of specimen	Dust collecting top windows	No dedication for different kinds of traffic flows
Lack of unobstructed patient viewing area	Vertical circulation location and number		Improper location and lack of specimen collection space	Uncontrolled and Unnecessary accesses	
Lack of IPC assisting spaces	Lack of proper isolation		Controlling of overcrowding on imaging waiting area	Unplanned ORs	
Traffic control issue	Over crowding		Managing of different traffic crossings	Vertical circulation accessing restricted areas	
	Lack of proper segregation of triage and patient viewing spaces			Overlap between clean and dirty lines	
				Lack of proper layout	

Table 7. Medical professional Gap ID

Design professional gap ID					
Aabet ER	Alert ER	Aabet Diagnostic	Alert Diagnostic	Aabet procedure	Alert procedure
Small attendant waiting	Minimum size considerations	Sample collection and transportation	Patient waiting location	Minimum number of minor procedure	Few standard consideration
Exposed resuscitation	Narrow entrance and triage area	Lab needs alternative space from crowded area	Incapable of providing full imaging service	Size of OR rooms	Everything is clustered around a single circulation
Lack of barrier on exam/ treatment areas	Poor triage location and distribution	Proportioning Number of diagnostic imaging with patient flow to the unit	Size of emergency lab	Proper traffic management	No dedication for different kinds of traffic flows
Few designated support spaces	Vertical circulation location and number		Improper location and lack of specimen collection space	Uncontrolled and Unnecessary accesses	Few support spaces
Lack of IPC assisting spaces	Lack of proper isolation			Lack of important support functions	Difficult to perform full fledged services
Unnecessary crossing of different traffics	Over crowding			Vertical circulation accessing restricted areas	
Isolation room safety	Lack of proper segregation of triage and patient viewing spaces			Overlap between clean and dirty lines	
Non- portioned spaces with too many patients				Unnecessary staff crossings	
Longer travels to vertical circulations					

Table 8. Design professional Gap ID

SOLUTION IMPLICATION SUMMARY

Medical professional solution implication	
Aabet Hospital Solution implication	Alert Hospital solution implication
Improving overcrowding and traffic flow are common among ER, diagnostic and procedure areas. Then comes improving program provision specially IPC programs and proper layout and finally finishing materials and ventilation systems.	For incoming and leaving patient traffic management, separate vertical circulation for patient, staff and equipment, controlling overflow of people through segregating the authorized and unauthorized personnel. Provision of IPC programs like hand wash stations OR traffic management improving the patient waiting and flow to the laboratory and medical imaging, improving transportation of specimen, specimen collection location, improving patient transportation and overflow in medical imaging units. segregation of patients and other traffic
Design professional solution implication on Aabet Hospital	
Design professional A	Design professional B
Patients at each process through the medical service should better be contained and monitored to control infection. Spaces such as the resuscitation area and orange exam/ treatment space needs to be controlled. Surgical unit needs to be redesigned with proper channel for all the traffic flows and should include all the necessary supply storages. First Basement floor has a proportionally higher load and patient traffic to this floor needs to be shared to other floors. In summary the hospital has proper accommodation but poor arrangements of facilities and poor channeling of different traffics	Emergency medical service area should be redesigned for better patient handling and control of infection following appropriate guidelines and prioritizing functions vital for the process than secondary functions like rehabilitation. Furthermore, facilities related to infection control like bathroom, hand wash etc should be placed with proper spacing. First floor has a potential to be housed by surgical department with appropriate traffic flow including equipment processing and ICU. Services on the first basement should be shared to other floors to ease the stress of too much patient flow. In conclusion the hospital has almost all appropriate services needs further

necessary for healing process. Therefore, redesigning it with better caution for this parameters will have a potential to improve services in the hospital.	adjustments for proper service flow and patient safety.
Design professional solution implication on Alert Hospital	
Design professional A	Design professional B
The exam/ treatment area needs much improvement on patient flow management and provision of the necessary programs with proper layout. It also needs better strategy to receive and process patients without congestion on the receiving area which also suggests for preferably horizontal or vertical expansion. Surgical department demands a deeper space and trying to redesign with the current space will not present much different result. Generally it will be better to build another structure than trying to improve the existing one.	As the trauma center has wider spaces around for expansion, it can take advantage for expansion and provide appropriate size of accommodations for the necessary service. Furthermore, if surgical unit can be brought to ground floor and expand to the neighboring free space, it will have opportunities to be redesigned fulfilling the standard requirements for trauma surgical unit. Therefore, based on trauma hospital design and considering all the shortcomings this center cant be properly improved unless all the structural system is changed.

Table 9. Solution implication Summary

COMPARISION OF SOLUTION IMPLICATION BY DESIGN PROFESSIONALS

Filtering common suggestion of a professional on both hospitals	
Design professional A common improvement suggestion	Design professional B common improvement suggestion
Improving layouts and provision of services while controlling patients moving through the process of medical service with the proper segregation from other traffics can improve the infection safety in the treatment process. It also minimizes congestion at each step in treatment process which is another contribution for infection prevention. A surgical department needs to be improved on its traffic management, provision of IPC functional spaces and contain enough space for a standard service provision.	ER spaces should contain enough space and prioritize to accommodate for the incoming patient traffic that should be properly handled for better infection control. Surgical department needs to contain enough space for appropriate service provision and prioritize proper traffic management control infection. Furthermore, facilities related to infection control like bathroom, hand wash etc should be placed with proper spacing. Units with higher flow of patient than can be controlled through transfer to expansion spaces within or outside the existing structure.

Table 10. Filtering common professional suggestions

COMPARISION OF ALL SOLUTION IMPLICATIONS

Comparison of summary of suggestions		
Design professional suggestion summary	Medical professional suggestion summary	Policy makers and NGOs suggestion summary
- Improving layouts and provision of appropriate service spaces - Give due attention to patient traffic - Provision of proper supply, clean and dirty spaces with IPC assisting materials and equipments - Surgical units and procedure spaces demand minimum traffic flow and avoid overlapping.	- Improving overcrowding and traffic flow are common among ER, diagnostic and procedure areas. - improving program provision specially IPC programs and proper layout and finally finishing materials and ventilation systems.	- Necessary strategies during design ▪ Proper layout of programs ▪ Traffic control and management ▪ Proper material specification ▪ Water supply and sanitation management - Traffic control and management to handle overcrowding - Design and construction follow up authority for healthcare facilities is essential - Appropriate placement of materials and equipments of IPC during design and construction stage. - IPC assessment manual for design stage needs to be prepared - IPC related spaces needs to be one of the basic requirements within a healthcare facility

Table 11. Comparison of summary of suggestions

5.5. SUMMARY

This chapter discussed the detailed feedback of each data collection process, analyzed it in the process of answering each research question and reached to findings that are suggestive to the favor of the hypothesis that is initially discussed on the first chapter of this research paper.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1. CONCLUSION

The objective of this thesis project was to assess the impact of patient centered architectural design approach to prevent and control infection in hospital setting by using case study of selected trauma hospitals. It tried to achieve this goal through a systematically designed research method to answer the questions of the research such as:

- Understanding the level of HAI through literature and situational study of case hospitals
- Understanding the impact of architectural design and patient centered architectural design process through case study and professional assessment.

Based on the analysis of literature, medical professionals, government regulatory body and concerned NGOs, the status of HAI in Ethiopia is not well studied but according to international studies done on developing countries, the slight attempts of studies we have and interviews and observations made on case hospitals, it can be concluded that there is a considerable level of infection in Ethiopian hospitals. Taking variables which discussed in the literature, it can be implied the situation in trauma hospitals to be worse.

Based on the interviews, observation and medical and design professional analysis of cases studies its learned that architectural design plays significant role in improving the condition of HAI in healthcare settings and further trauma hospitals. But due to various gaps at the policy level, coordination of various units under the authority of healthcare related regulatory body, implementation of existing strategies and lack of responsible regulatory body, is leaving professionals unattended. This resulted in minimum contribution of design for IPC of current hospitals in the country.

The comparison table on the synthesis of findings suggests that Patient centered architectural design approach have a great potential being a core for most parameters that should be included in designing trauma center.

Therefore patient path will be a core concept while arranging all functional programs and linking each unit in order of medical service provision. Furthermore, professional recommendation will be tested through designing an alternative deign using the proposed design approach on one of the case hospital. Accordingly, the researcher tests this design approach by redesigning Aabet hospital as it is identified to have a better potential to accommodate changes comparing the suggestion given to each case hospitals.

6.2. RECOMMENDATION

After reviewing and concluding on the findings based on the collected data and case studies recommendations are made for different groups who are role players and end users on healthcare environment from designing until utilization stage. Therefore the recommendation is categorized into the following four groups.

1. Recommendation for policy makers
2. Recommendation for hospital administration
3. Recommendation for general public
4. Recommendation for hospital designers (Architects)

6.3.1. Recommendation for policy makers

- Prepare guideline and implementation strategy for patient center design approach as it is showing a promising change on healthcare sector.
- create or assign a team for evaluation, permit and follow up of hospital projects
- require qualification test instead of CV
- Giving training on physical infection control approaches for designers through seminars and training workshops.
- testing certifying designers on hospital design

6.3.2. Recommendation for hospital administrators

- Adopt patient centered service strategy for their hospital.
- Keep close attention to a design process and involve in a better decision making
- Get training on how to utilize the hospital spaces, paths and circulations from hospital designers and consultants
- Give training for every newly arriving staff
- Refrain from changing spaces, circulation and any other physical components of the hospital without consulting with a qualified consultant
- Include IPC department as one of the main administrative units of the hospital
- Follow up if the staff is following the hospital protocol and the intension of the hospital design.

6.3.3. Recommendation for general public

- Properly read signage’s and act according to hospital regulation

- ❖ Refrain from accessing unauthorized areas
- ❖ Cooperate in the process of managing overcrowding

6.3.4. Recommendation for hospital designers (Architects)

Two types of recommendation is given for design professionals

A. Recommendation on further research

This thesis was focused on the impact of physical (design) approach out of which on traffic control approach, even out of that patient traffic management approach which can be utilized to control infection within the healthcare setting and finding methods of implementing on designing and renovating a hospital project.

As per the findings, this showed a promising potential towards a better controlled hospital environment. Therefore, the author believes that if similar researches related to physical and traffic control approaches are further researched for contribution on IPC and identify ways of implementation on design process, there will be ample data to achieve the maximum contribution of architectural design to control infection in healthcare setting.

B. Recommendation on how to utilize the patient flow based design approach

- Priorities for patients
- Starting with summarizing the process of healing (patient process) through receiving treatment. This can help identify the major patient paths through receiving treatment and helps as input for patient centered design approach.
- Calculating the incoming patient traffic for peak, average and lowest times and design every facility and units accordingly
- Identify the time a patient spends in each unit and calculate the total time of a patient to complete a full treatment. Then prepare the proper facility at every step.
- Avoid any form of delay more than acceptable range at every unit through identifying the causes of delay and solving them.
- Identify and prioritize patient traffic over other traffic flows without compromising the efficiency of the service.
- Designate all patient traffic from other traffics and facilitate easy transition from one unit to another based on the developed “healing process”.

- Set up the staff accommodation planning based on the healing process. This can be like "distribution of specialized workers on a factory assembly line".
- Dedicate a path for patient traffic that will be minimally shared by other traffic flows.

CHAPTER 7

DESIGN PROPOSAL

PROGRAM COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS

GROUND FLOOR PLAN SC 1:100 **EXISTING**

INCLUDED PROGRAMS

- Exam/ Treatment Rooms
- Triage
- Staff changing
- Physiotherapy
- Medical imaging
- Emergency Lab
- Isolation
- Minor Procedure

GROUND FLOOR PLAN **PROPOSED**

INCLUDED PROGRAMS

- Exam/ Treatment Rooms
- Triage
- Staff changing
- Medical imaging
- Central Lab
- Isolation with ante room
- Procedure waiting
- Minor Procedure
- Family Waiting with bath rooms
- Staff changing with bath rooms
- Clean and soiled supply rooms
- Separate clean supply vertical circulation
- Emergency pharmacy

COMPARISON

- Non vital programs for emergency service such as physiotherapy is moved to another floor.
- A defined waiting area for family is provided with bath rooms adjacent to them.
- Central laboratory with the necessary specimen collection space for emergency unit and blood bank is provided following the healing process.
- Exam/ treatment spaces are provided in a smaller spaces with smaller number of patients in a single space with a proportional nursing space and supplies.
- Isolation space made to contain Ante- room for air born infection control
- One more procedure space is provided with the necessary physical isolation from other traffic flow
- More Supply spaces are provided on the necessary places

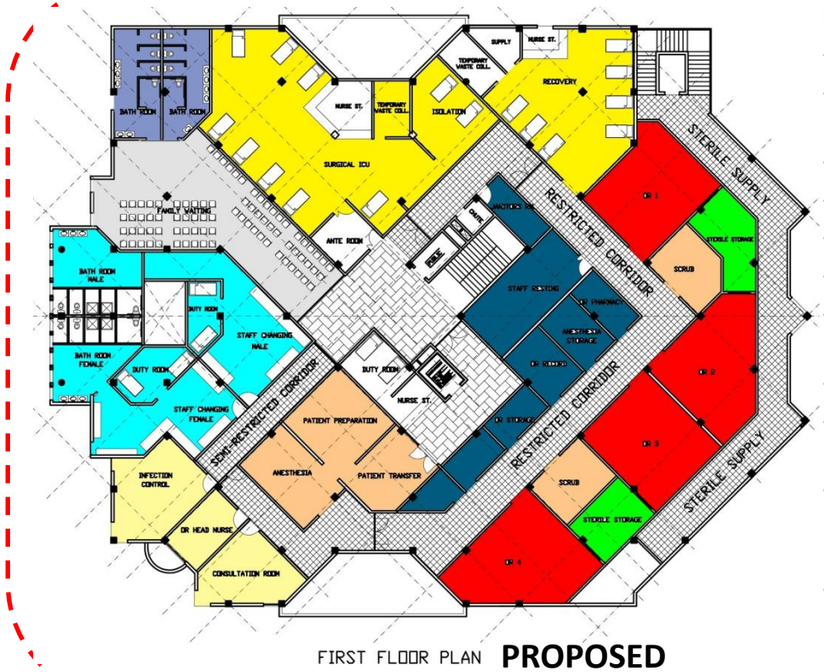
PROGRAM COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS

FIRST FLOOR PLAN SC 1:100

EXISTING

INCLUDED PROGRAMS

- Operating theatres
- Patient preparation area
- Sterile supply
- Restricted corridor
- Recovery
- Staff changing
- OR staff accommodation
- Burn Unit
- Staff changing with bath room
- Decontamination
- Hydrotherapy
- Skin grafting
- physiotherapy



FIRST FLOOR PLAN **PROPOSED**

INCLUDED PROGRAMS

- Operating theatres
- Patient preparation area
- Sterile supply
- Restricted corridor
- Recovery
- Staff changing
- OR staff accommodation
- ICU
- Staff changing with bath room
- Designated family waiting with bath room
- Office for consultation and infection control officers

COMPARISON

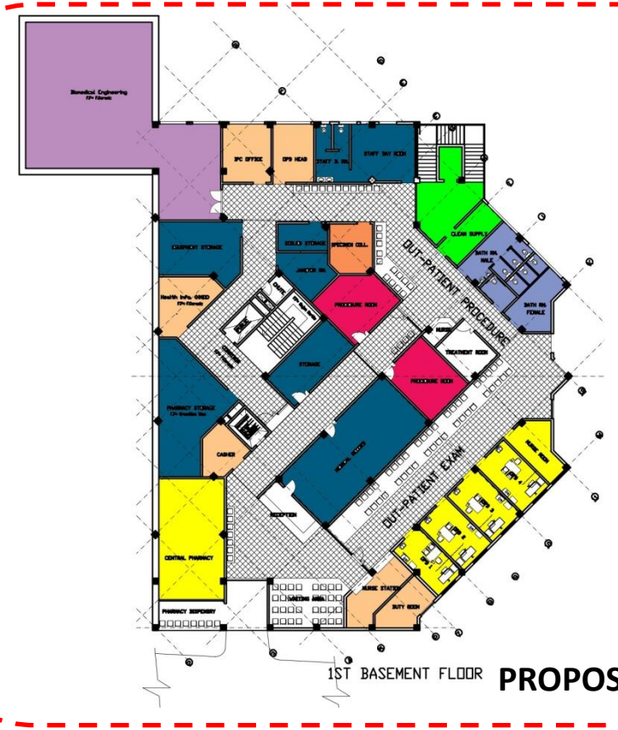
- Standardizing operating theatre spaces accommodations for them is given priority resulting in moving function like burn unit, physiotherapy and hydrotherapy to other floors and bringing surgical ICU to this floor.
- Appropriate accommodation for family is provided.
- OR support spaces, vital staff accommodations are provided.
- Segregated sterile supply path and vertical circulation is provided.

PROGRAM COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS

EXISTING

INCLUDED PROGRAMS

- Patient waiting
- Patient record
- Examination rooms
- Casher rooms
- Central pharmacy with storage
- Central Laboratory
- Support and medical staff spaces
- Minor procedure
- Additional Staircase to ground floor



PROPOSED

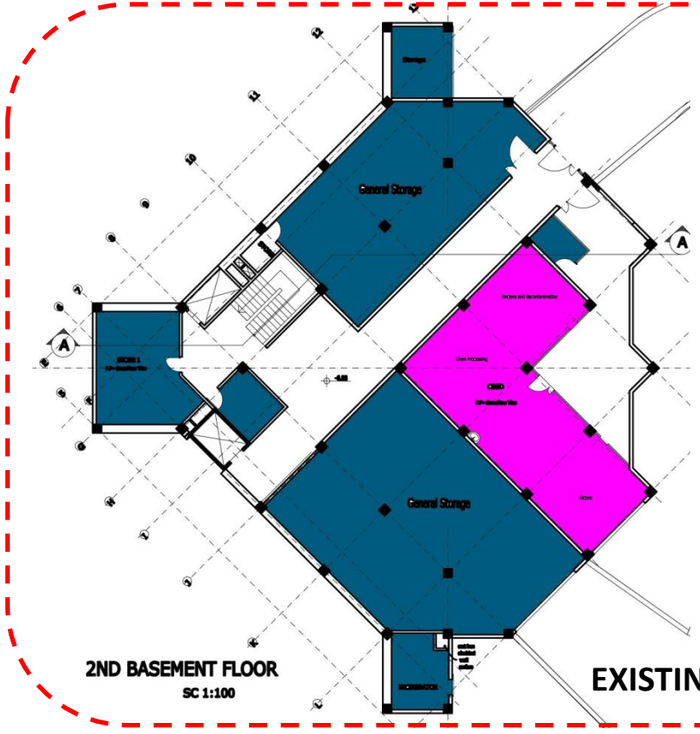
INCLUDED PROGRAMS

- Patient waiting
- Patient bath room
- Patient record
- Examination rooms
- Casher rooms
- Central pharmacy with storage
- Support and medical staff spaces
- Minor procedure
- Additional Staircase to ground floor
- OPD Laboratory
- Staff room
- Staff bath room
- Staff changing room

COMPARISON

- Three major units of the hospital can create overcrowding on one floor therefore central laboratory is moved to another floor leaving enough space to accommodate missing patient and staff functions of OPD unit.
- Accordingly patient waiting is made to have enough natural light and ventilation from opposite sides with bath rooms adjacent to it.
- Separate clean supply vertical circulation is added to bring sterile supplies to the floor.
- The stair linking this floor to ground floor alone is removed for creating obstacle and low functionality while increasing circulation quality.
- Staff bath room, resting space and changing spaces are included.
- Central pharmacy with storage is moved to another side of the floor to increase the quality of patient flow.

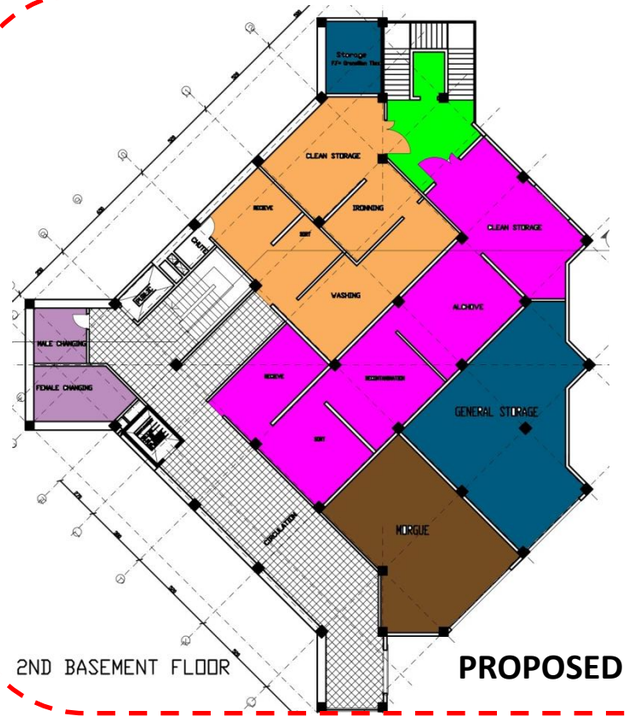
PROGRAM COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS



EXISTING

INCLUDED PROGRAMS

- Central sterile supply department (CSSD)
- Storages
- Morgue



PROPOSED

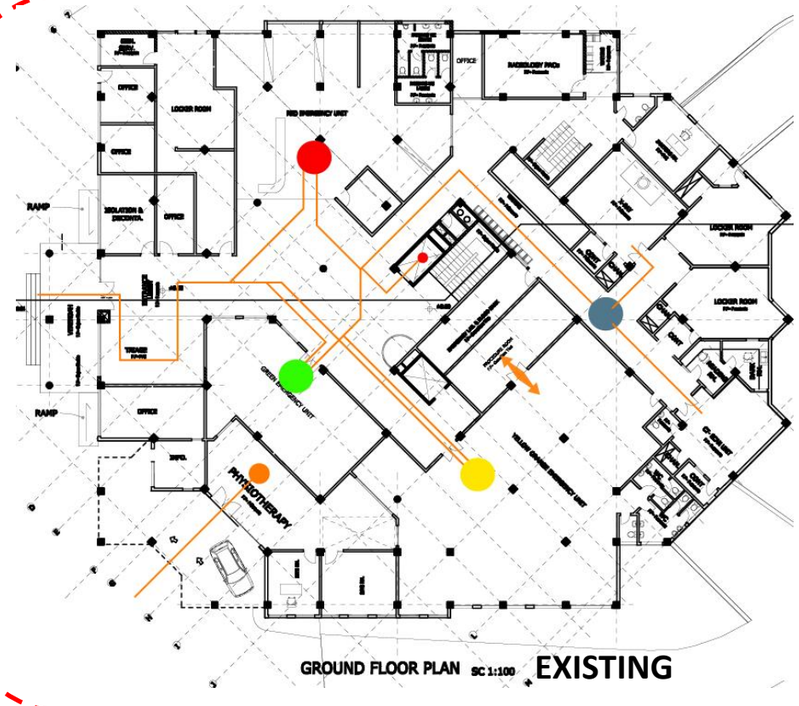
INCLUDED PROGRAMS

- Central sterile supply department (CSSD)
- Storages
- Laundry
- Morgue
- Staff changing

COMPARISON

- CSSD collection and supply spaces and lines are designated and working spaces and process are controlled for infection.
- Laundry space with soiled linen chute and collection area and direct connection of the clean linen to the sterile supply is provided.
- Staff Changing space is provided.

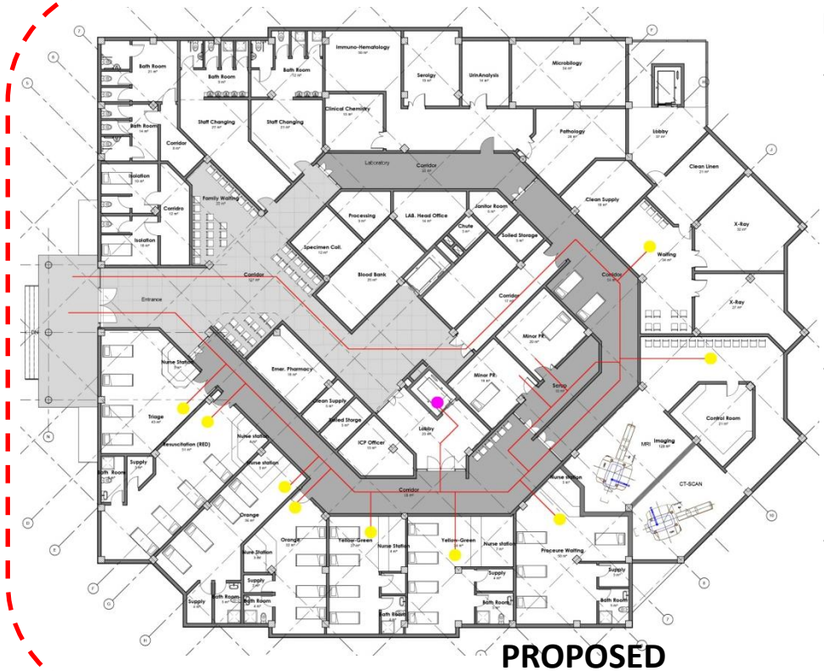
PATIENT FLOW COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS



EXISTING

PATIENT FLOW PATH

- Incoming patient passes through triage if resuscitation is not necessary and goes to the Exam/ Treatment spaces.
- Patient will have the chance to be isolated if infectious disease is detected.
- After exam/ treatment spaces patients are forced to go back and forth through the treatment path and even across treatment spaces.



PROPOSED

PATIENT FLOW PATH

- Incoming patient passes through triage if resuscitation is not necessary and goes to the Exam/ Treatment spaces.
- Patient will have the chance to be isolated if infectious disease is detected.
- Patient goes through a linear path of treatment process.

COMPARISON

- The proposed design arranges the design programs according to the treatment process flow. It takes a linear, unidirectional path by arranging the patient accommodation following the outer perimeter of the building volume and keeping the programs adjacent to each other.
- Staff accommodations are arranged in the center opposite to the patients to keep the flow of patients uninterrupted.
- Supply paths, family waiting spaces are kept away from the primary patient path.

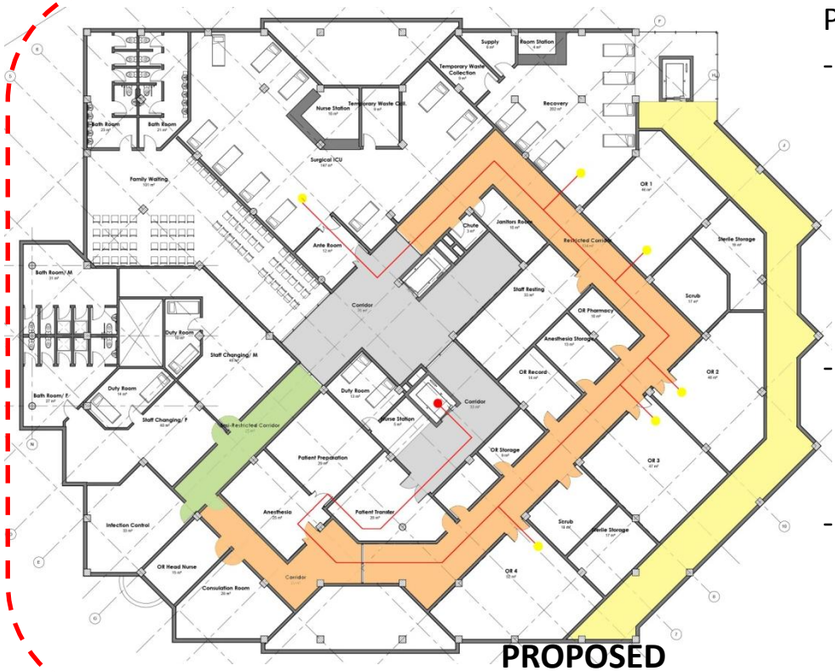
PATIENT FLOW COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS

FIRST FLOOR PLAN SC 1:100

EXISTING

PATIENT FLOW PATH

- Patient comes through either of the elevators at the center of the building and goes into a restricted corridor.
- Anesthesia room precedes patient preparation
- Second elevator interrupts restricted corridor
- Patient path makes back and forth movements before reaching recovery



PROPOSED

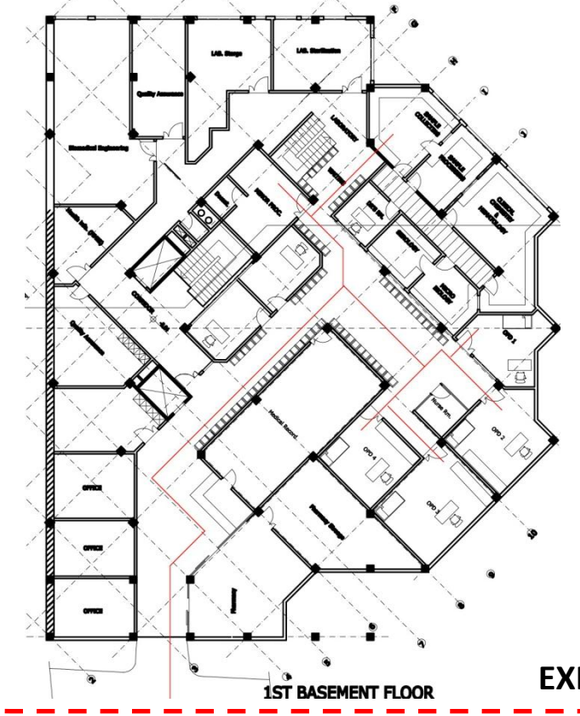
PATIENT FLOW PATH

- Patient comes through a dedicated elevator at the center of the building and goes into a restricted corridor passing through a nurse station.
- Appropriate patient transfer, preparation, and anesthesia process.
- Patient moves through a linier forward path within the treatment process.

COMPARISON

- Programs are moved to other floors to make room for appropriate programs that can make a better patient flow and treatment path.
- Uninterrupted linear paths are achieved through arranging patient treatment spaces following the outer perimeter of the building volume and arranging support spaces in the center opposite to patient spaces.

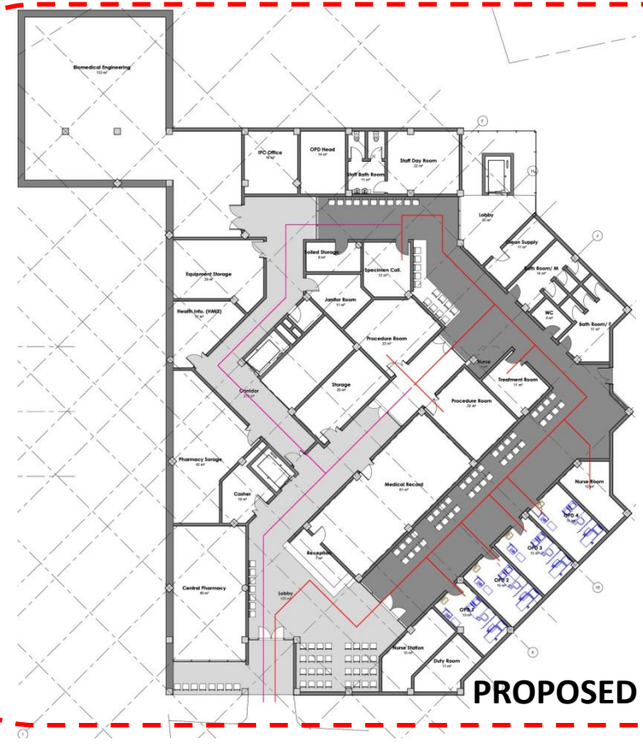
PATIENT FLOW COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS



EXISTING

PATIENT FLOW PATH

- Incoming patient registers and waits at OPD waiting for examination.
- Proceeding to diagnosis and procedure takes to overlapping paths and waiting.
- Patient registration and pharmacy dispensary share common space leading to infection through overlapping and overcrowding



PROPOSED

PATIENT FLOW PATH

- Incoming patient have enough waiting area before registration and waits at OPD waiting after for examination
- This layout also allows linear patient flow through adjacent arrangement along the perimeter.
- It segregates the pharmacy towards the exit side of the patient path and dispensary waiting is arranged on the external side of the building.

COMPARISON

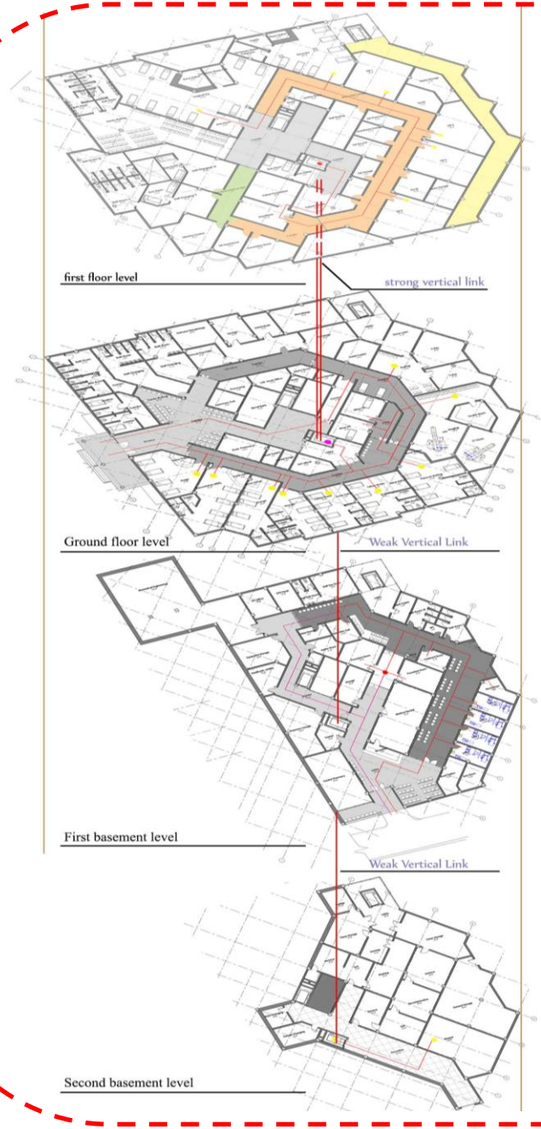
- Linear paths achieved through perimeter adjacent arrangement of patient treatment spaces.
- Overcrowding is managed through distributing waiting spaces and scattering programs that create crowds.

PATIENT FLOW COMPARISON BETWEEN THE EXISTING AND PROPOSED PLAN LAYOUTS

VERTICAL PATIENT FLOW

- Patient flow from emergency to surgical area and inpatient area is frequent.
- Patient flow from OPD to surgical area and inpatient area are low.
- Patient discharge can be made through public elevator
- A necessary link between OPD and medical imaging
- Deceased patients from emergency, OR and wards will be taken to the morgue through the restricted patient elevator.

EXISTING



VERTICAL PATIENT FLOW

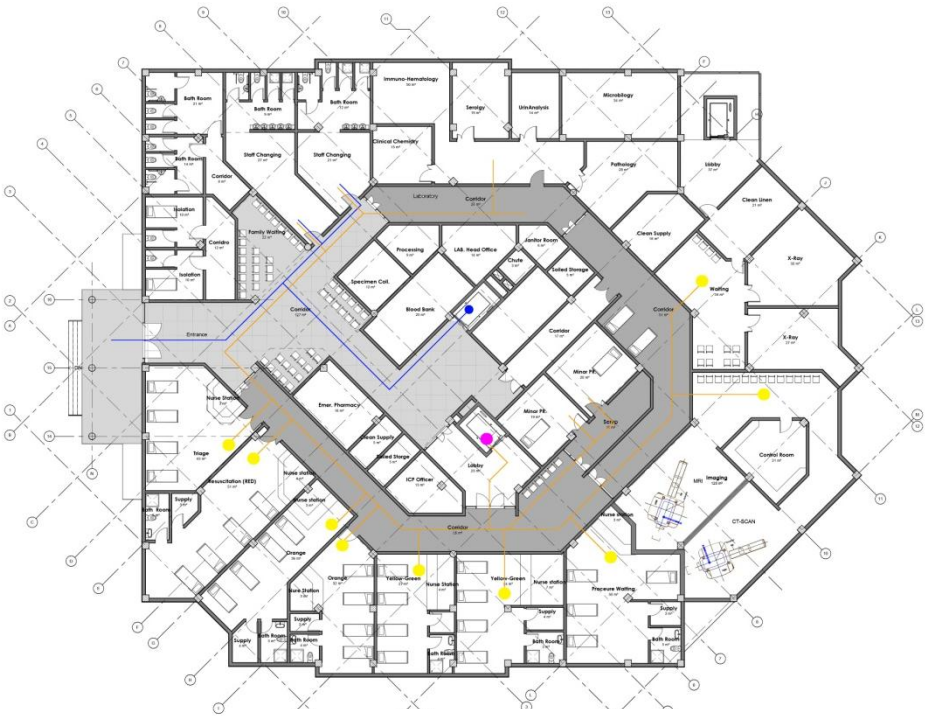
- Patient flow from emergency to surgical area and inpatient area is frequent.
- Patient flow from OPD to surgical area and inpatient area are low.
- Patient discharge can be made through public elevator
- A necessary link between OPD and medical imaging
- Dedicated elevator takes patients vertically.
- Dedicated elevator is proposed for sterile supply.
- Deceased patients from emergency, OR and wards will be taken to the morgue through the restricted patient elevator.

PROPOSED

ANNEX

Ground floor supply plan

1 Ground Floor
1 : 100

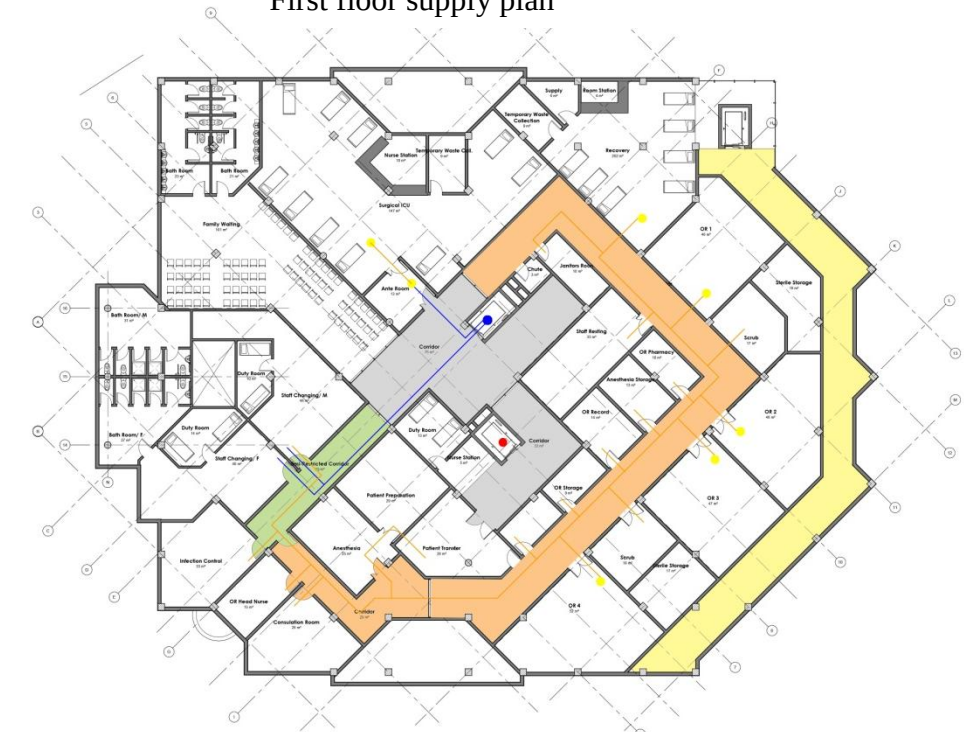


Ground floor staff flow plan

1 Ground Floor
1 : 100

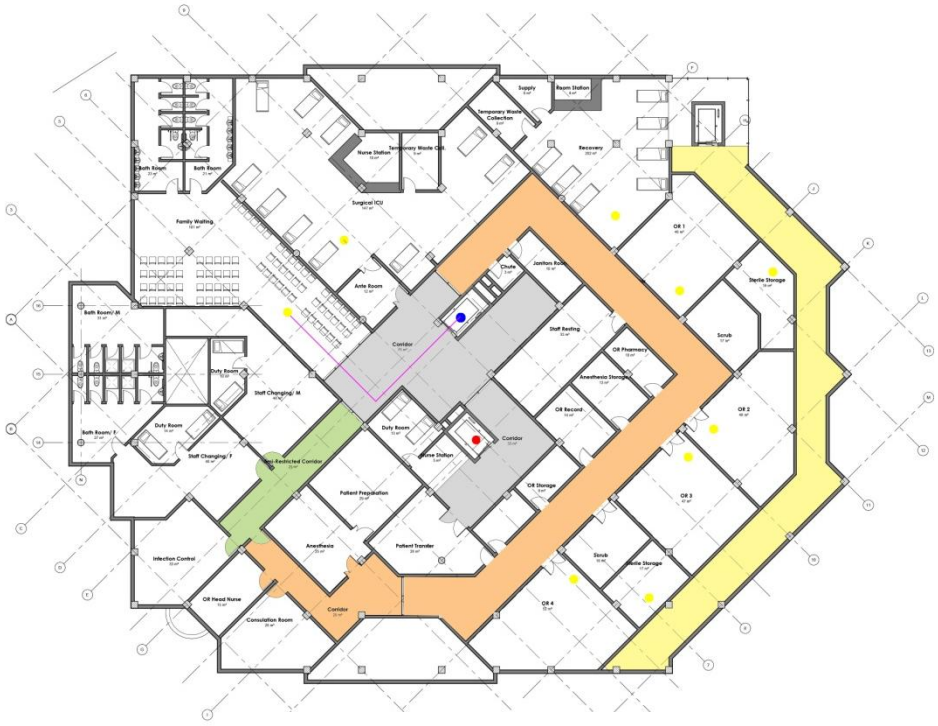
1 First Floor
1 : 100

First floor supply plan



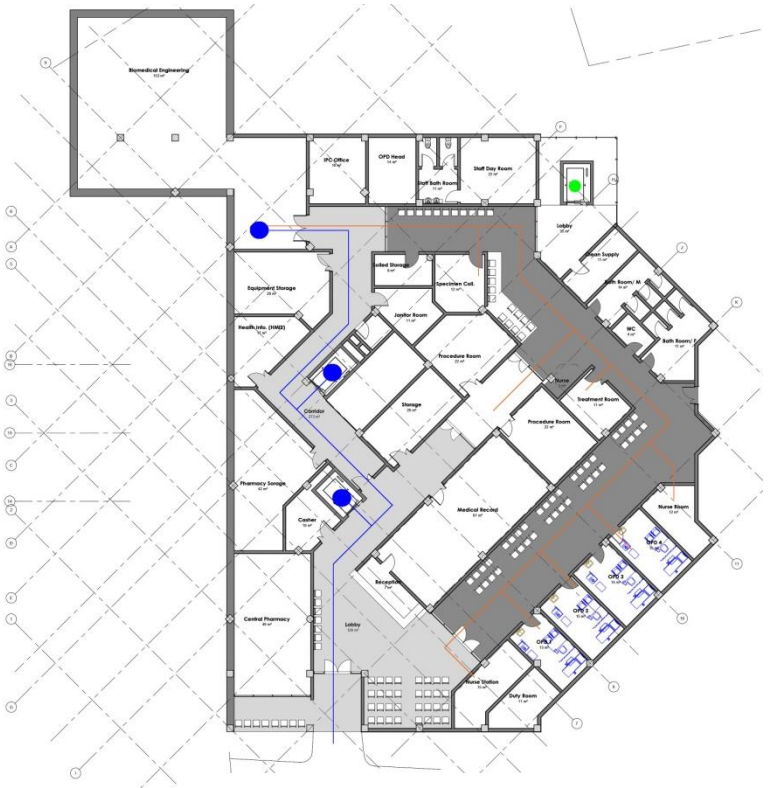
1 First Floor
1 : 100

First floor staff flow plan



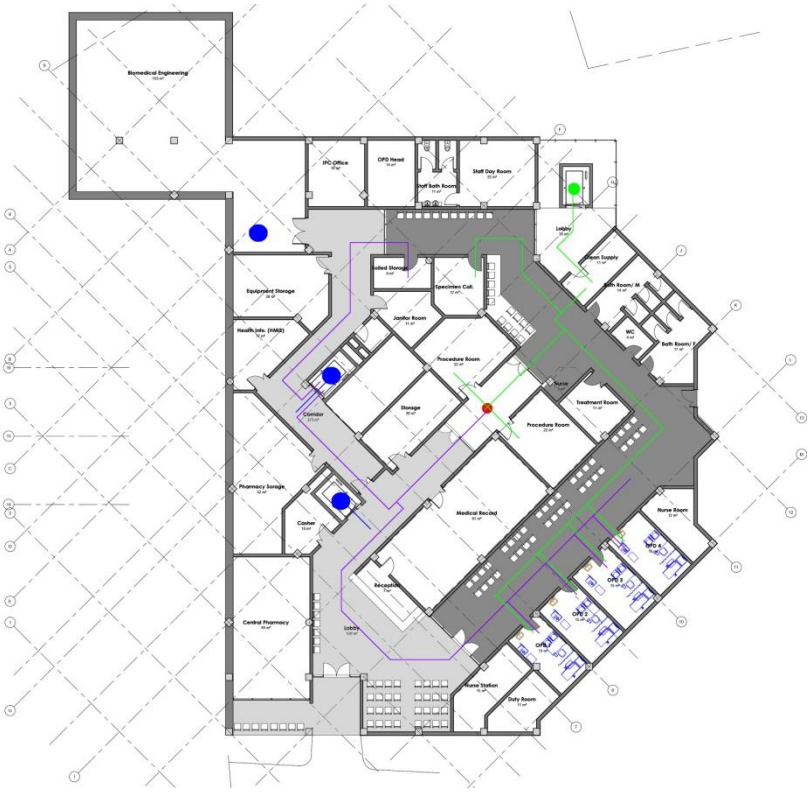
1 First Floor
1 : 100

First floor Attendant flow plan



1 1st Basement Floor
1 : 100

First basement staff flow plan

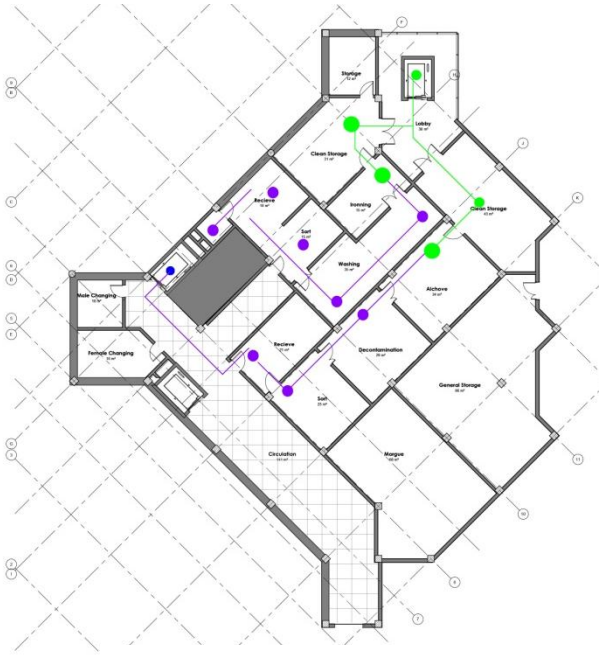


1 1st Basement Floor
1 : 100

First basement supply flow plan

Second basement staff flow plan

1 2nd Basement Floor
1 : 100



Second basement supply flow plan

1 2nd Basement Floor
1 : 100

BIBLIOGRAPHY

Published sources

Worku, Walelegn et. Al., 2016, *Point prevalence of hospital-acquired infections in two teaching hospitals of Amhara region in Ethiopia*, DO: 10.2147/DHPS.S107344, Drug, healthcare and patient safety

M. C. Emre Simsekler, James R. Ward & P. John Clarkson (2018): *Design for Patient Safety*: A Systems-based Risk Identification Framework, Ergonomics, DOI:10.1080/00140139.2018.1437224

Anjali Joseph, Mahbub Rashid, 2007, *The Architecture of Safety*: Hospital Design

Ali et al. *Antimicrobial Resistance and Infection Control* (2018) 7:2 DOI 10.1186/s13756-017-0298-5

American Institute of Architects Academy of Architecture for Health (AIA-AAH), *Planning, Design, and Construction of Health Care Facilities*, Third Edition, 2015,

Rutherford PA et. Al., *Achieving Hospital-wide Patient Flow*, IHI White Paper. Cambridge, Massachusetts: Institute for Healthcare Improvement; 2017.

The Health Research & Educational Trust of the American Hospital, Association American Society for Health Care Engineering, Association for Professionals in Infection Control and Epidemiology, Society of Hospital Medicine, *Using the Health Care physical Environment to prevent and Control Infection*, University of Michigan, CDC, 2015

Dr, Ivy s Cheng, 2016, *emergency department crowding and hospital patient flow*: Influential factors and evidence informed solutions, Stockholm

Quach C, McArthur M, McGeer A, et al. *Risk of infection following a visit to the emergency department: a cohort study*. *CMAJ*. 2012;184(4):E232-E239. doi:10.1503/cmaj.110372

Martin, M et al., *Mapping patient flow in a regional Australian emergency department*, International Emergency Nursing (2010), doi:10.1016/j.ienj.2010.03.003

Ana Carolina Potier Mendes et.Al, *hospital master plan: the role of the architect, methods of elaboration and characterization of Brazilian production*, 2007

Health Building Note, 2017, *Infection control in the built environment* (HBN 00-09)

Facility Guideline Institute, 2012, *Guidelines for design and construction of health care facilities*

Potisek et. Al., 2007, *Use of patient flow analysis to improve patient visit efficiency by decreasing wait time in primary care-based disease management programs for anticoagulation and chronic pain*, 10.1186/1472-6963-7-8

WHO, 2004, *Practical Guidelines for Infection Control in Health Care Facilities*

CDC, 2003, *guidelines for environmental infection control in health-care facilities*, recommendations of CDC and the healthcare infection control practices advisory committee (HICPAC)

Ethiopian ministry of health, Ethiopian hospital management initiative, 2016, *Ethiopian hospital services transformation guidelines,* Volume 1

Dr. Fatimah Lateef, 2009, *Hospital design for better infection control*, Journal of Emergencies, Trauma, and Shock

Federal ministry of health, 2012, *infection prevention and patient safety reference manual for service providers and managers in healthcare facilities of Ethiopia*

Online sources

https://www.who.int/news-room/fact-sheets

https://www.cdc.gov/globalhealth/countries/ethiopia

https://www.wikipedia. org

Medical dictionary, 2018