DESIGNING A LOCALLY ADAPTABLE LOW COST PATIENT WARD BED IN UGANDA:

A CASE STUDY OF ATUTUR HOSPITAL, KUMI DISTRICT

BY

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DECLARATION

I Akol Otemor Benard declare that this research report is my original work and has neither been produced nor submitted by any person to any Institution of Higher Learning for any academic award.

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APPROVAL

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DEDICATION

I dedicate this research to GOD ALMIGHTY for providing me with the resources required to accomplish my studies, to HIM BE THE GLORY.

I cannot forget my wives Vicky Akwongo and Esther Anyango, my children, KONGAI Rachel Akol, ARERENG Favour Akol and OKURUT Prosper Aber, who have been my constant source of inspiration. They gave me the drive and discipline to handle my studies with enthusiasm and determination.

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ACRONYMS

CIA	Central Intelligence Agency (world fact book)
HC II	Health Centre II (Located in every Parish)
HC III	Health Centre III (Located in Sub County)
HC IV	Health Centre IV/ Health sub district (Located in every County)
NHS	National Health Services (UK)
NRH	National Referral Hospitals
RRH	Regional Referral Hospitals
UBOS	Uganda Bureau of Statistics
UNHRO	Uganda National Health Research Organization
USA	United States of America
VHTs	Village Health Teams
WHO	World Health Organisation
NHS	National Hospital Service of UK
UK	United Kingdom
MRRH	Mbarara Regional Referral Hospital.

DEFINITION OF TERMS

Health: Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO constitution, 1986). It is a right that every human being has by virtue of being human.

Hospital bed: Hospital beds and other similar types of beds are used not only in hospitals, but in other health care facilities and settings, such as nursing homes, assisted living facilities, outpatient clinics, and in home health care. While the term hospital bed can refer to the actual bed, the term bed is also used to describe the amount of space in a health care facility, as the capacity for the number of patients at the facility is measured in available beds.

General ward: Is a health facility hall that accommodates more than two in-patients beds without structural boundaries or un penetratable partition. A health facility room where many in-patients beds are arranged together with limited space/gap in between the beds. These are generally shared hospital rooms of accommodation for in-patients, also sharing lavatories and sanitation facilities.

Loxodonta: This is an African Elephant that lives in the savannah, because of its robust body size and strength; other predators do not take any advantage against it. It is an inspirational object for this study. Its body parts gave an inspiration for various bed parts and functions.

Backrest Hospital Bed

This is the bed used in public and private health facilities. It has an adjustable backrest that provides patients with comfort to some extent. Instead of holding a patient to a particular position, a mechanically adjustable front of the bed is adjusted to the elevation of the patients comfort.

ABSTRACT

Uganda, like any other developing country experiences challenges in providing access and quality health services to its people. Uganda has tried to put in place the necessary infrastructure though with limitations. Many hospital facilities that have buildings do not have enough equipment such as beds to support the patient's numbers. Although World Health Organisation recommends a global average of 25 beds per 10,000 people, in Ugandan hospitals, the density of beds stands at 5 beds per 10,000 people. This condition has left many Ugandans spreading mattresses or mats on the floor making it difficult to be properly examined and also exposing the patients to various infections. This study therefore set out to design a low cost general ward bed with improved functions using available local materials. Specifically the study analysed the effects of the low bed patient ratio in health facilities, developed a design of a low cost bed inspired by a Loxodonta, and produced a prototype of a low cost general ward bed. The study used a case study design and studied Atutur hospital in Kumi district. Respondents were purposefully selected and a total of 29 participated. Using in-depth interviews, observations and photography, the views of the respondents were collected and used to design a low cost general ward bed. The design developed was also based on the Loxodonta which is a common African gene. The final prototype of the bed demonstrated that it is affordable and multifunctional.

CHAPTER ONE: INTRODUCTION

1.1 Background to the study.

In 651 AD, Hôtel-Dieu was founded in Paris by Saint Landry and is considered to be the first hospital in the city and the oldest worldwide still operating today. It was a multipurpose institution which catered for the sick, poor, offering shelter, food and medical care. By 1788, even though Hôtel-Dieu was the largest of Paris' hospitals with 1,200 beds, many beds held three or more patients– women gave birth in shared beds and there was no separation amongst patients with contagious diseases (Wikipedia)

Hospitals emerged at the end of the 18th century in many countries as a place where the ill are treated (Ackerknecht, 1967; Foucault; 1973). These hospitals were organised on the basis of large open wards fitted with beds which were run by a nursing team headed by the nursing 'sister'. The doctor visited the ward on a regular basis to go round the beds (rounds) and see his or her patients. This particular configuration of medical work has remained the dominant mode of hospital clinical practice for the last two centuries. Today, beds have remained an important component of any hospital setting in most parts of the world especially for in-patient wards. Hospital beds are manufactured by specialized skilled fabricators who take care of patient's needs and the health worker's specifications required for attending to the sick. Brian (2006) observes that America, England and Japan, are the leading manufacturers of hospital beds for varying use. World Health Organisation (2012) recommends a global average of 25 beds per 10,000 people to be appropriate for each country.

According to World Health Organisation (2012), Marianne (1993), countries such as Monaco, Japan, North Korea, South Korea and Russia, are among the leading providers of hospital beds for patients in their health facilities. These countries have developed their own general hospital ward beds to a tune that Monaco has 165 beds per 10,000 people, Japan has 137 beds per 10,000, North Korea has 132 beds per 10,000 people, South Korea has 103 beds per 10,000 people and Russia has 97 hospital beds per 10,000 people. This is the

beds per 10,000 people and Russia has 97 hospital beds per 10,000 people. This is the highest number of hospital beds among developed countries and more than three times the American ratio of 30 hospital beds per 10,000 people.

The low bed patient ratio affects many countries in the world. Katie (2017), observed that there is National Health Service (NHS) hospital bed shortage crisis in UK despite UK being a first world country. In UK hospitals for example, 100 per cent of their beds are always in use. Matt (2017) observes that in some hospitals such as Essex, it takes up to 27 days for one to find a free bed and that two patients died on trolleys in hospital wing A and E. As a result, 42 emergency departments were forced to divert ambulances to other hospitals, NHS doctors are being forced to choose who lives and who dies as a shortage of intensive care beds. Contrary, Germany has three times as many free beds compared to the UK, with 82 available beds per 10,000 people, while France has 62 free beds for the same population, compared to 27 hospital beds available per 10,000 inhabitants in the UK.

The ratio of beds to patients is a worldwide phenomenon, as defined by Zaman (2005) that beds are private places which become a public place in a general ward. This is certainly true in Bangladeshi hospital where an orthopaedic ward is designed to accommodate 85 beds but it has 100 or more patients on average. The extra patients are placed on the floor of the ward and forcing other beds to be placed close to each other. The Bangladeshi hospital bed density stands at 6 beds per 10,000 people. According to USA Central Intelligence Agency (2010), among the East African states, Burundi has 19 hospital beds per 10,000 people, Rwanda has 16 beds per 10,000 people, Kenya has 14 beds per 10,000 people, Tanzania has 7 hospital beds per 10,000 people while Uganda's hospital bed density, stands at 5 beds per 10,000 people.

In Uganda, overcrowding of patients is one of the major challenges experienced in hospitals. Mubangizi (2014) observed that in Mbarara Regional Referral Hospital (MRRH), paediatric ward designed to accommodate 50 patients, houses above 75 patients on an average. Sometimes babies have to share a bed. Bronwen (2014) observed that in Fort portal Regional Referral Hospital in Western Uganda, hundreds of pregnant women and their family members wait for their turn to consult a doctor in the hospital gardens. As they move

into fully fledged labour, some of the lucky expectant mothers get one of the six hospital beds available in the labour ward. The luckiest might even get a bed with a mattress. Lots of the women arrive from very far away. They come on their motorbikes or bicycles in labour. They hang around the gardens of the hospital for some time, days or weeks until they are coming into labour. The labour ward only has about six beds so the midwives bring them and then if they are not about to give birth they send them out to the gardens again. This situation limits the freedom of women as patients and usually many get problems during delivery.

With the rising population in the country and low GDP, Ugandan hospital wards require to be provided with more inpatients ward beds. The beds should be user friendly, taking considerations for the patients, medical workers specification and affordability. This could support the country's health system and increase access to health service at low cost.

The study reflects from the history of western medicine in Uganda, how the need for ward beds came in health care as early as 1897 to date. According to Hamu Mukasa (1899), the coming of western medicine in Uganda was through Dr. Albert Ruskin Cook and Sister Katherine Timpson who started medical work in Uganda on February 22, 1897 at Mengo and under a tree as a clinic.

Today, the aim of Uganda's health system is to deliver the national minimum health care package. Uganda's health system is divided into national and district-based levels. At the national level are the National Referral Hospitals (NRH), Regional Referral Hospitals (RRH), and semi-autonomous institutions including the Uganda Blood Transfusion Services, the National Medical Stores, the Uganda Public Health Laboratories and the Uganda National Health Research Organization (UNHRO)

The issue here is that, the cost of imported hospital beds is so high such that it increases the cost of providing health services in different countries. The fact that countries are unable to acquire modern beds, locally manufactured beds visible in health facilities across the country could be redesigned with many functions to meet the requirements of use in a general ward bed. These beds would provide an alternative sustainable solution to the expensive beds that are imported and which in most cases are not enough. The few imported

modern beds end up being used by the upper class of citizens who are in private rooms and able to meet the cost.

In Atutur General Hospital located in Kumi District, Eastern Region of Uganda, there is a serious need of hospital beds and other equipments. The majority of beds available in wards are ordinary plain beds with limited functions, while the few imported beds with improved functions for ideal patient care, and have been placed at the intensive care unit. The hospital caters for a population average of 700,000 people. According to Otim, R. (2013), Atutur hospital is in Teso sub Region, serving the population from the districts of Bukedea, Kumi, Ngora and Pallisa.

1.2 Problem statement

Although the government of Uganda is increasing the infrastructure in health sector to provide better services to patients, government has not yet allocated enough resources to procure enough ward beds with improved function for ideal patient care. Consequently, patients lie on the floor, women deliver children on floors of health facilities, while some are forces to deliver from homes. This results into loss of lives, difficult for doctors to attend to patients. The general ward beds are not enough and this negatively impact on service delivery and delays the recovery period of patients. Mothers lying and giving birth on floors have increased chances of getting infected rather than being protected from infections. There is scarcity of sustainable bed designs with improved functions that take care of patient's needs and the health worker's specifications required for attending to the sick in Uganda. There is no manufacturer of low cost adaptable ward beds with improved functions that could minimize floor cases where most patients end up sleeping, making treatment complicated.

1.3 Purpose of the study

To design a low cost general ward bed with improved functions using locally available materials that are affordable.

1.4 Specific Objectives

1. To find out what type of bed designs are available in Hospital
2. To analyse the effects of low bed-patient ratio in health facilities
3. To develop a design for a low cost ward bed inspired by an African Elephant using locally available materials

1.5 Research questions.

1. What types of bed designs are available at Atutur Hospital?
2. What is the effect of low bed-patient ratio in health facilities?
3. Which design can be developed as a prototype for a low cost ward bed using local materials?

1.6 Significance of the study

The study contributes to the improvement of health care delivery in Atutur hospital and other similar health facilities by designing and making the prototype ward bed that shall be fabricated in large numbers. The study provides the world of academia with the relevant information, data and design for anyone to bench mark on and carry further research.

This study provides the government and other development partners with an opportunity of procuring enough adaptable ward beds with improved functions at a reduced cost compared to the imported beds of the similar functions. The availability of affordable ward bed in health facilities lessens new infections in the wards as all the ward occupants will be on beds. Government shall save the money spent on importing beds, on medicines and other supplies. The bed design increases the comfort and safety to its users hence, facilitating early recoveries and creating more time for production. Because of the facilitated early recovery for patients, government shall spend less on medicines and supplies. The policy makers may adopt the use of these beds in all health facilities due to the functionality, affordability and low maintenance costs. The completed prototype enables the researcher to get recognition for the innovation and own the copy and property right.

The design will increase the number of beds at Atutur general hospital hence, giving all patients access to the beds and reducing on the infections caused by lying on floors and mosquito bites due to lack of mosquito net hanging provisions for patients and their attendants in the wards.

1.7 The scope of the study

This covers the geographical, content and the time taken in the study.

1.7.1 Geographical scope

The study was conducted in Atutur General Hospital, Kumi district. Atutur General Hospital is located in Eastern Uganda, 240km from Kampala Capital city, along Mbale to Soroti highway. On Google maps, the locating coordinates are 1.4078389, 33.9871437, and 16.25

1.7.2 Content scope

The study investigated the various types of bed designs available in the hospital, where these beds are placed and why they are placed where they are. It also analyzed the bed-patient ratio in wards and the materials used for making existing ward beds. The study further analyzed the relationship between the available imported contemporary beds, the materials being used for making them, the purchase and maintenance costs as opposed to developing the low cost bed with similar functions using the locally available materials.

1.7.3 Time scope

The study was conducted between the months of August 2017 to July 2018. The total duration was 12 months.

1.8 Limitations

The study is limited to the design processes and production of the prototype for low cost ward bed for health facilities in Uganda using the locally available resources.

CHAPTER TWO: LITERATURE REVIEW

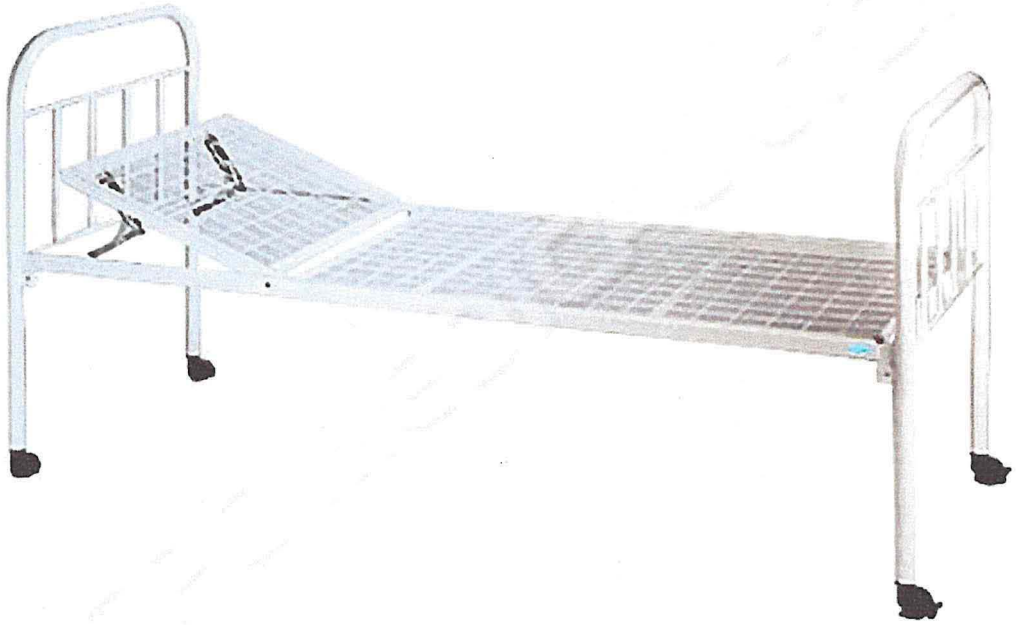
2.1 Overview

This study aimed at designing a low cost hospital ward bed with improved functions using the locally available materials and inspired by a Loxodonta. The literature provides the insight of the types of bed designs available in the hospital, analysis of the bed-patient ratio in health facilities, the materials used in making the ward bed, the functions provided by the ward beds, affordability and different aspects involved in producing hospital ward beds. It also discusses how related challenges have been handled outside the Ugandan settings.

2.2 Existing Ward Bed Designs in the wards

According to Global Products Corporation (GPC) Medical limited (2008), one of the Indian manufacturers and exporters of plain hospital beds, the plain hospital bed has remained popular in many countries due to its affordability and maintenance related costs. The plain bed is made out of Frame made of epoxy-coated steel, head ends with 4 vertical bars, rigid mesh mattress platform, legs with plastic feet, knock down construction and within the size 1900mm x 800mm x 500mm. The hospital bed (Figure 2.1) with bars and backrest, is made out of frame made of epoxy-coated steel, head ends with 4 vertical bars, rigid mesh mattress platform with castors 100mm, two castors with brakes and with overall size of 1900x800x500mm. The beds are made out of steel angles, tubes, plates and hollow sections which are pre-treated and powder coated. The standard hospital beds measure 1980mm x 910mm x 500mm. The standard bed is designed bearing in mind that it will occupy patients of varying sizes.

a) Plain Hospital Beds



b) Hospital Bed with Bars and Backrest

Figure 2. 1: Plain and back rest hospital beds
Source: www.gpc.medicalltd

The beds shown in figure 2.1 a and figure 2.1 b, are the common beds visible in Atutur Hospital and similar health facilities across Uganda. Many of these beds are locally made and procured. They are affordable and easily maintained. They are majorly made from mild steel tubes and hollow sections which are readily available in the country. This study seeks to improve on the design of these beds and integrate the functions of imported ones. GPC Ltd further manufactures other modern beds which include Fowler Position Bed also called Deluxe (Figure 2. 2). The Fowler Position Bed is designed with backrest and knee-rest adjustable by two separate crank levers from foot end, mounted on four castors of 10cms (two with brakes), measuring 1980mm x 910mm x 600mm. Basically made out of steel angles, tubes, plates and hollow sections which are pre-treated and powder coated

Figure 2. 2: Fowler Position Hospital Bed with Leg and Backrest
Source: www.gpc.medicalltd

The bed in figure 2.2 supports the patients lifting of the back and legs without handling. The limitation of this design is that the front rear ends are made out of hard steel. In cases where the bed occupant becomes unconscious, such a patient may end up knocking and injuring him/herself. Like many other imported beds, this bed does not have any provision for mosquito net hanging. The bed is imported into the country, making it expensive. This

study is looking onto improving the design of this bed by providing the front and rear ends with soft decorative materials, designing attachments that will be used for hanging mosquito nets when required and side protecting rails. According Volker, (2012) The Chairman Executive Board of the Germany Volker hospital beds manufacturing company, Volker hospital beds (figure 2.3) are designed with scissors mechanisms, levers, springs, cables, wheels, angle bars, alloy plates, stainless steel and are covered with decorative plastic with the aim of producing a bed that gives patients a real sense of well-being – in short, a bed that promotes wellness and fast recovery.

Volker Hospital Bed with Rails and Backrest

Figure 2. 3: Volker Hospital Bed with Rails and Backrest
Source: www. Volkerhospitalfurniture

Volker hospital beds shown in figure 2.3 are designed with the back and leg rests and safety rails among other functions. It is a comfortable bed imported into the country at very high

costs. Volker beds are few in the country due to the costs involved in procuring them. They are in some intensive care units of health facilities, although they were supposed to be in all wards in this trend of technology. Many of the functions of Volker beds shall be integrated in the design of the low cost ward bed.

Although some of the existing bed designs are well thought of, they are very expensive and therefore cannot be affordable in Uganda and more so in Atutur Hospital. Even the patients occupying the few available improved beds are faced with the challenge of securing the mosquito net during the nights. This leaves them getting exposed to mosquito bites and consequently infected with the killing malarial parasites.

2.3 Bed-patients ratio in health facilities.

According to the World Health Organization 2015), the developed counties in Asia lead the world in bed densities in their health facilities, followed by European countries, north and south America and most African countries fall below the global average. Comparing the Ugandan hospital bed density of 5 beds per 10,000 people with that of Japan, Germany, and Kenya, Japans Hospital bed density as of 2014 is 132 beds per 10,000 people. This is far beyond the global average of 25 beds. Germany has 83 beds per 10,000 people. It is also above the world health recommendations. Kenya has about 14 beds per 10,000 people. This is slightly beyond a half of the World health Organisation recommendations of 25 beds per 10,000 people. Ugandan hospital bed density is even below half the global average. This leaves the country with the dire need for innovation into the hospital bed design and development.

According to CIA World Fact book (2017), there are 92 countries in the world having hospital bed densities of above 25 beds per 10,000 people. This indicates that half of the world countries are below the global average. In Africa, the countries with high hospital bed densities are Gabon, with 63 beds per 10,000 people. Gabon was ranked country number 19 globally. Ethiopia has 63 beds per 10,000 people. Ethiopia is ranked country number 20 globally, followed by Libya with 37 beds per 10,000 people, ranked number 59. Generally, in Africa, only five countries are above the global average hospital bed densities. These include Gabon, Ethiopia, Libya, Mauritius and Namibia. According to WHO (2012) statistics, Tanzania has about 7 beds per 10,000 people; Kenya has 14 beds per 10,000

people compared to Uganda with 5 beds per 10,000 people. Mwananchi (2012) observed that scenes of two or more expectant women in a bed or some even sleeping on the floor have become quite common in public hospitals in Tanzania. The country is having fewer beds on general wards compared to the increasing number of patients.

Although the General Hospitals, Regional and National Referral Hospitals have continued to make major contributions to essential clinical care in Uganda, numerous reports (including those of MoH) are awash with the stark reality of lack of beds and other supplies, resulting into avoidable deaths among other problems (HURINET-U, 2012). Hospitals started in Uganda way back in February 1897, when Dr. Albert Cook and wife Lady Kate Timpson Cook (Nursing Sister) arrived in Kibuga, Mengo. According to Hamu Mukasa (1899), three days later after arriving at the Kabaka's court, Dr. Cook started treating the sick native patients under a tree as a clinic. Three months later, Dr. Cook set up his hospital in a grass-thatched, reed-walled structure, with 12 wooden beds and straw for mattresses which he used for seeing over 60 patients daily. The wooden beds whose stands were poles of tree stamps dug into the soil and a papyrus mat on. He named it Mengo Hospital after the Kabaka's Royal Palace nearby; although today it is known as Namirembe Hospital, named after Namirembe hill. Two years later, Dr. Cook expanded the health facility to 40 beds. Dr. Cook kept increasing ward beds in his hospital to match the then growing number of patients.

According to the Uganda Hospital and Health Centre IV Census survey (2014), the public/government health Centre IVs and Hospitals have 5 beds per 10,000 people, while privately owned for profit/non profit Hospitals and Health Centre IVs, have 4 beds per 10,000 people. Hospital beds help to indicate availability of in patient's services. The survey paints a picture that both public and private Hospitals and Health centre IVs in Uganda have an average of 5 beds per 10,000 people. This bed density is similar to the average bed density in the African region (10 beds per 10,000 population) but far from that of the world Health Organisation (2012) recommendation of an average of 25 beds per 10,000 people. Although some private facilities may have beds available, many citizens cannot afford the charges and therefore resort to self medication. It is therefore incumbent upon government

to increase the access of health care to its people by increasing the number of beds in the public hospitals and Health centre IVs. The Uganda Hospital and Health Centre IV Census survey (2014), also showed that 30% of these beds were in HC IV, 50% in General hospitals, 13% in Regional Referral hospitals and 7% in National Referral hospitals. That the bed density in Eastern Uganda of 4 beds per 10,000 population) was substantially lower than in other geographical zones of Central, Western and Northern regions (5 –6 people per 10,000 population). Volker, (2012) stated that every person has a right to be treated with respect and dignity, especially people in need of health care. That the reaction of patients to their environment is influenced by a combination of psychosocial impulses and psychobiological predisposition. These influences can result in elevated stress or a self questioning sense of well-being. According to Dilani (2015), an awareness of the causes of good health requires design concepts that promote well-being. The quality and nature of a patient's environment should be seen as effective instruments for supporting and improving recovery. You can ask, why do people become ill or conversely why do some people enjoy good health in spite of a demanding lifestyle? These questions suggest that psychological factors influence individual health.

In most parts of Uganda, hospital beds remain scarce. In Fort portal Regional Referral Hospital, women could not access beds when they come to deliver, they would remain in the hospital gardens because of lack of beds in the wards. Women would go in for check up in the ward and after, return to the gardens (Bronwen 2014, Doyle 2013). In a similar situation, Mafabi (2013) observed that in Mbale Regional Referral Hospital which is one of the 13 regional referral hospitals in Uganda and also designated as one of the three public clinical paramedical teaching hospitals in the country, the number of patients and their attendants without hospital beds but admitted to wards is unbelievable.

CIA world fact book (2017) published a list of countries with their hospital bed densities per every 10,000 people. Countries were ranked according to the bed-patient ratio, though the year of information gathering from between 2006-2012. According to several records collected worldwide by various stake holders in health sector, it is not only Uganda grappling with lack of hospital ward beds. Some developed and developing countries also fall short of the recommended 25 hospital beds per 10,000 people (see appendix 4)

Green (2002) observed that hospital health care providers need to plan bed capacity based on standards that reflect the ability to place patients in appropriate beds. That general ward bed placement should be done in a manner that infection control is made possible and that the appropriate general ward bed should be provided with the necessary adjustments and provisions to promote infection control, provide patients with required comfort and safety from any internal or external risk of falling off the bed.

2.4 Designs for a Low Cost Hospital Ward Bed Using Local Materials.

According to Volker (2012) the regularly used materials for hospital bed making include: metal or mild steel, angle bars, hollow sections, carbon steel, stainless steel, plastic, metal plus ABS, foam, levers, bolts and nuts, rivets, wheels, paint, pulleys and leather. Steel alloys are not commonly used as they make the bed more costly. Hospital beds should be designed to reduce the formation of hospital infections through the use of several elements, which together will achieve this goal. The materials should allow the assembling process, and provide characteristics such as strength, durability and resistance to chemical or weather conditions.

According to Suzhou Qinghai Medical Equipment Co.Ltd (2017), Anmat is one of the largest manufacturer and distributor of medical beds and supplies in China, providing high quality and price competitive products that serve more than 50 countries worldwide. The materials used by Anmat for bed making are stainless steel, paint, mild steel, steel alloys, aluminium, plastic, rubber wheels, pulleys, bolts and nuts among others. According to Portillo, Santacruze, Morales & Gamboa (2016) The design and manufacturing of affordable medical assistive devices represents a major challenge for developing countries where resources are much more limited than in rich countries. The engineering design process focuses on developing better devices and systems with a low impact on the environment and the most functional and efficient performance, at the lowest possible price. According to the U.S. Department of Health and Human Services-Food and Drug Administration & Center for Devices and Radiological Health (2016), when evaluating the safe use of a hospital bed, component or accessory, manufacturers and caregivers should recognize that the risk for entrapment may increase if a hospital bed system is used for purposes, or used in a care setting, not intended by the manufacturer. Reducing the risk of entrapment involves a multi-

faceted approach that includes bed design, clinical assessment and monitoring, as well as meeting patient, resident, and family needs for vulnerable patients in most health care settings- hospitals, long term care facilities, and at home.

Today, the Ugandan iron and steel industry has grown at unprecedented rate due to the booming housing and construction sector in the region (URA, 2010). Steel tubes, hollow sections, angle bars, flat plates, steel and aluminium chequered plates, are among the products manufactured and available in the market in Uganda. The researcher has taken on to improve on the design of the Fowler Position Bed by providing safety guard rails and detachable front and rear stands that give the provision of hanging a mosquito net. With the abundant hydro electric power, steel, foam, leather, paint and wheel products in the country, the design and fabrication of the low cost ward bed is viable.

CHAPTER THREE: METHODOLOGY

3.1 Overview

This chapter presents the research design, the study area, the study population and data collection methods used in this study.

3.2 Research design

The research design for this study was a case study. According to Yin, Merriam, and Stake (1998) case studies are meant to make an intensive investigation on the complex factors that contribute to the individuality of a social unit. Bogere & Gesa (2015) stated that case studies emphasize detailed contextual analysis of a limited number of events or conditions and their relationships, adding that the findings of case studies can be generalized to represent other cases in a population of interest. Case study research design is an empirical inquiry that investigates a contemporary phenomenon within its real life context (Stake, 1995)

The researcher chooses this design because it provides a systematic description that is factual and accurate, thereby enabling the researcher to understand the real situation facing the inpatients in the general wards. It gave the researcher the picture of the general ward set up, the condition and design outlook of existing beds, the materials used for making them, where the beds were imported from and at what cost. This supported the researcher in making cost effective analysis of the proposed design verses the existing beds in the general wards.

According to Musiimenta (2011) using the Case study design over other research designs enables the researcher to use more than one case study that made it possible to get an in-depth understanding of the meanings attached to the intervention as well as stakeholder experiences of using the intervention within different social and organisational settings.

3.3 Study Area.

For purposes of this study, the researcher considered Atutur General Hospital as a case. Atutur Hospital being a general hospital with high numbers of patients seeking health care on daily basis represented the general hospitals across the country. Atutur hospital serves about three districts of Kumi, Bukedea and Ngora. Also being among the early health facilities in Uganda, it gave a picture of the fate of similar hospitals across the country. Atutur hospital was built with the capacity of 100 beds but currently admits about 150 in-patients on average. The hospital has employed medical staff, Administrative staff and support staff based on the 100 bed capacity. This study collected data from the patients, care givers, hospital staff and the community living around the hospital.

3.4 Study population

Babbie (2011) defines a study population as that group (usually of people) about whom we want to draw conclusions. For this study, the target population included all patients, attendants and staffs in Atutur hospital. The target population was 200 participants, while the sample size was 30 respondents. This includes the hospital staff, the patients and their attendants. For this study, 30 respondents were contacted. Of these, the study considered the inpatients occupying 12 beds in four different wards, 6 medical staff who were providing healthcare in the respective wards, 2 administrative staff one of which was the hospital superintendent and the other being the in charge hospital equipment maintenance and repairs. 10 attendants for the in-patients were also sampled. Among the inpatients, were 3 expectant mothers in the maternity ward, 4 in-patients in the paediatric ward, 2 patients in the male ward and 3 patients in the female ward. This is in conformity with Sekaran and Bougie (2010) who contends that the sample size larger than 20 and less than 500 is appropriate for most studies; though this is dependent on the size of the target population. For this study, this represented 12% of the sample size. Responses from respondents were recorded and analysed.

3.5 Sampling procedure and sample size

According to Amin (2005), sampling is the process of selecting the elements from a study population in such a way that the sample elements selected represent the population. Simple random sampling and purposive sampling was used in this study to ensure proper representation of the target population. Bryman (2008), states that: purposive sampling is a method that entails selecting respondents in a strategic way, so that those sampled are relevant to the research questions being posed. This approach increased the reliability of the information collected in the respective wards. The choice of the wards was purposively selected by the researcher since the target population was spread in all these wards. The respondents were those that were found in the ward and a simple random were taken to give chance to everyone in the ward to be selected. For the medical staff, the respondents interviewed were those who were found in the wards attending to the patients at that time and a random sample was taken to give every medical staff in the ward to be selected. For the administrative staff, the Officer in-charge of equipment and the hospital Superintendent were selected purposively and interviewed.

3.6 Data Collection Methods and Instruments

The methods used for collecting data in this study included interviews, observations and photography, while the instruments used were the interview guide, observation and photography check lists

3.6.1 Interviews

An interview is a oral process where the researcher gathers data through direct interaction with the participant. It is a dialogue between an interviewer and interviewee for the purpose of gathering data about the respondent. The researcher interviewed patients, attendants and hospital staff using an interview guide as an instrument that helped in controlling and directing the interviews. The researcher then moderated the interview sessions throughout the study as he recorded voices/views of the respective patients, attendants and staff. The researcher employed individual interviews, addressing the questions to a single respondent, one at a time.

3.6.2 Observation

The researcher observed the ward conditions; the beds where patients laid on, the bed designs available in each ward, the process of giving care to the bed occupants and the methods used for hanging mosquito nets at night. The researcher acted as a spectator on the health facilities, environment and behaviours of the participants and took note of relevant scenes. The researcher had earlier prepared an observation check list that guided on areas of interest to which he noted during the time when the hospital Administrator, Principal Nursing Officer and the In-charge hospital equipment took him around the whole hospital. Also each time the researcher visited a particular ward, office, wash room and store, an observation was made and notes taken.

3.6.3 Photography

Photographs of the wards, existing bed designs, bed arrangement, patients and their attendants in the wards and gardens, medical staff giving care to the patients, were taken and used to reinforce the data collected during interviews and observations. On each scene, the researcher requested the participants to permit him take photographs and on consent, photographs were taken.

3.7 Data analysis

The data collected was taken to the studio and analysed using the emerging themes. It was arranged according to the objectives and themes explored through studio. Various sketches, drawings and Marquette's were developed. The sketches were based on the loxodonta as an inspiration. Sketches and other drawings were then transformed into Computer aided drawings and design. Finally, a prototype of the ward bed with improved functions and features was produced using locally available materials to address the problem of shortage of beds in health facilities.

3.8 Validity and Reliability

Aron & Fraley (1999) stated that the validity of a measure refers to whether it actually measures what it claims to measure. The interview guide and observation check list were all tried at Banda Community Health Centre. Banda Community Health Centre provides medical care to patients from low income communities. With its daily high patient turn up, the health facility has only three plain ward beds: one for medical examination, one for treatment and the other for patients who require some rest before returning home or as they wait for referral. The research supervisor also guided the researcher on improvement of the instruments for validity. Reliability of an instrument is the ability of a given instrument to give required responses/answers each time it is used on the same phenomenon. The language used in the interview guides, conformed to this requirement on testing. The researcher also moderated the interviews to avoid deviating from the context. A face to face interview also helped the researcher get objected responses as it was not easy for respondents to give false information.

3.9 Ethical Considerations

It was a new and interesting experience working with the patients, attendants, medical staff and hospital Administrators. On submission of my introductory letter to the hospital management, the Hospital Superintendent asked me to hand in my research proposal to confirm that I am truly a master's student of Kyambogo University not a journalist. I submitted the research proposal and he endorsed on my letter of introduction but retained a copy of my proposal. He further called on the Principal Nursing Officer to take and introduce me to all the hospital staff that were on duty. I was allowed to be in the hospital any time of my convenience for data collection for twelve days. While in the hospital, respect for the staff, patients and their attendants was key. Passionate verbal and facial expressions helped the researcher to interact with the respondents. Smartness, time keeping and management were some of the ethical values that enabled the researcher to collect the required data.

As ethical issues have become cornerstones for conducting effective and meaningful research. As such, the ethical behaviour of individual researchers is under unprecedented scrutiny (Best & Kahn, 2006; Field & Behrman, 2004; Trimble & Fisher, 2006). In today's society, any concerns regarding ethical practices will negatively influence attitudes about

science, and the abuses committed by a few are often the ones that receive widespread publicity (Birch, Mauthner, Jessop, & Miller, 2002). The information contained in the data collection tools was carefully determined and communicated to a respondent in an effective manner by the researcher. The information that the researcher gave and presented through interpretation into a local language (Ateso) , was planned and presented so that it was completely understood, and fully understood by the respondent. It was the researcher's responsibility to see that this is accomplished. This perspective placed a great responsibility on the researcher and made an assurance that effective consent has been obtained from the respondent.

Where the participant involved in the study came face to face with the researcher, the researcher made a careful introduction about himself, stating the purpose of the study and why he thought it necessary to have dialogue with the participant. The researcher would then seek for the participants consent to share out the information requested of him or her. For those participants who consented to share the required information, the researcher assured the participant of the protection of one's identity and privacy and adding that this information was only required for the purpose of this study.

In the paediatric ward, the researcher found out that many sampled patients could not talk for themselves because they were children. The researcher preferred using substitute consent because the agreement to give the required information was made between the researcher and the care givers who most of which happened to be the mothers to the sick children. Drew & Hardman, (2007) stated that both direct and substitute consent must meet the requirements for informed consent from a legal standpoint, informed consent involves three elements: the first is that one understands and has the capacity to judge the researchers request, secondly, one can give the required information, and lastly one consents to give such required information with voluntariness.

CHAPTER FOUR: DATA PRESENTATION AND DISCUSSION OF THE FINDINGS

4.1 Overview

This chapter presents data, interprets and discusses it following the objectives. The chapter analyses the effects of low bed-patient ratio in health facilities, presents designs for a low cost general ward bed inspired by an African Elephant using locally available materials and shows a prototype outlook for the low cost general ward bed.

4.2. Types of ward bed designs found in Atutur Hospital

Zaman (2005) defined a bed as a private place which becomes a public place in a general ward. When the in-charge hospital equipment was asked to list down the types of ward beds in Atutur Hospital, he named plain, fowler position, paediatric, intensive care and labour beds. When asked to mention the difference in theses beds, he stated that plain beds are ordinary beds with only back rest. Fowler position beds do have leg and back rests and the stands are attached on wheels for mobility. Intensive care bed (volker) has leg and back rests, side safety rails, wheels attached to the stands and the bed is generally finished with soft protecting surfaces. The labour bed has no front rear and side safety guards rails but it is provided with a hydraulic mechanism of lowering or lift the bed to a required work table. When asked how mosquito nets are fixed on these beds, he stated that all the beds available in the hospital do not have a provision for hanging mosquito nets. That fixing mosquito nets is then left to the patients and their attendants/care givers

The researcher observed that the beds require regular maintenance. When the in charge equipment was asked when the last repair and maintenance of these beds had been carried out, he stated that it was carried out in 2016, about two years ago. Analysing the condition of the beds, the paint has peeled off in some parts, allowing rust to come in; some stands were not at 90^{o}.

Figure 4.2.1: Plain hospital bed
Source: Photograph by the Researcher, 2018

Figure 4.2.1 shows a row of plain hospital beds in one of the wards. They are made from mild steel tubes, hollow sections and angle bars, pre-coated to prevent rusting. Though these beds are cheap to procure and maintain, they do not offer the ideal medical care to its occupants

According to the Researchers' observation, the Fowler position bed is an improvement made on the plain bed in terms of design and materials. The limitation observed here in regard to maintenance, is the introduction of stainless steel framing and finishing to the bed. See figure 4.2.2

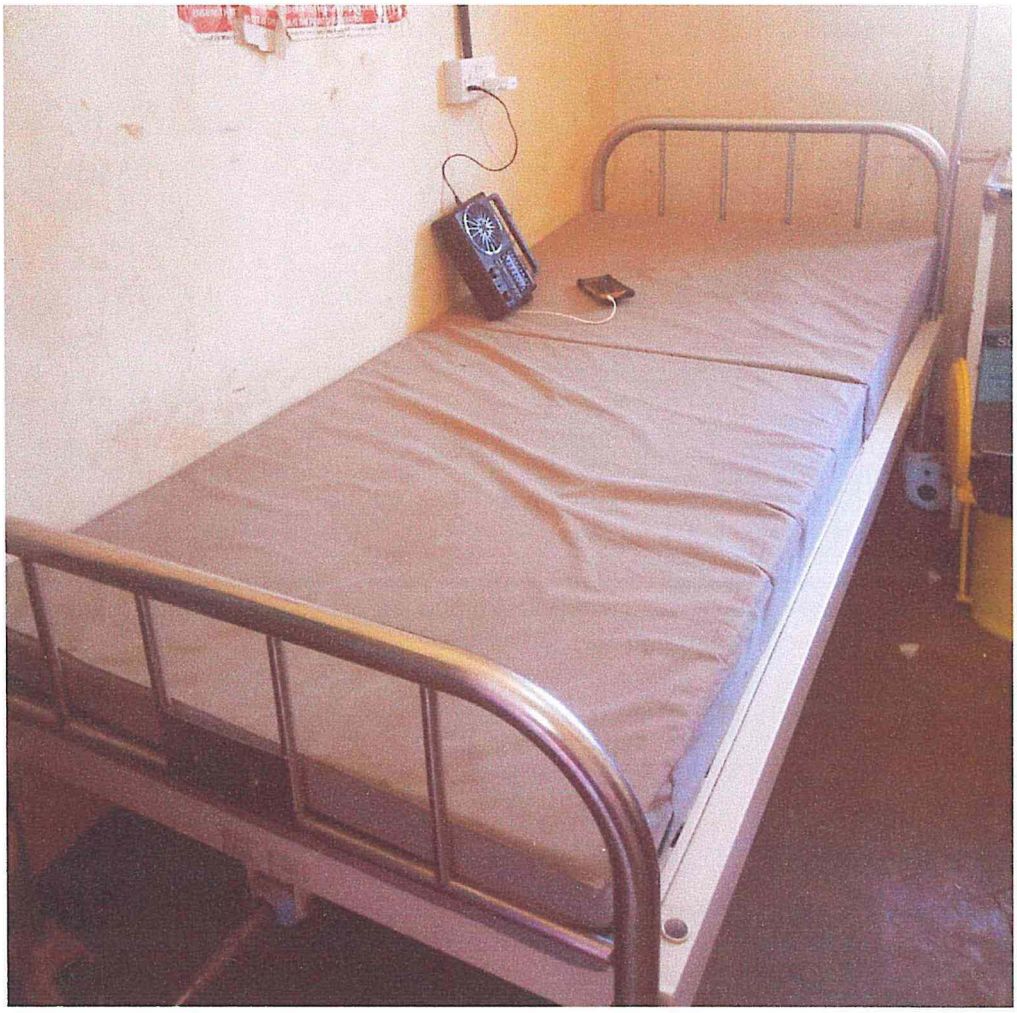


Figure 4.2.2: Fowler position bed
Source: Photograph by the Researcher, 2018

Figure 4.2.2 shows a Fowler position bed with leg and back rests. Made out of stainless steel and alloys, it is imported and supports the patient care requirements to some extent, its costly to procure and maintains as the stainless steel technology is still low in Uganda. The bed does not have side safety rails and mosquito net hanging provision.

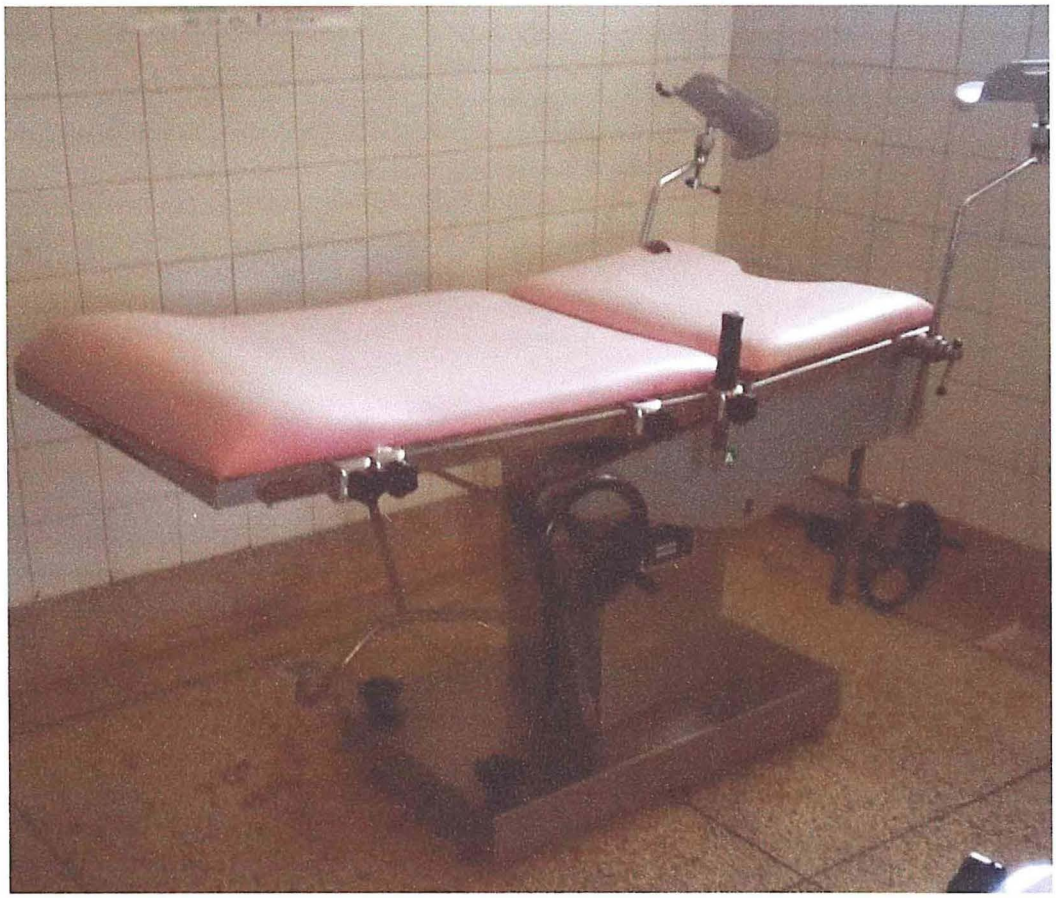


Figure 4.2.3: Labour bed
Source: Photograph by the Researcher, 2018

Figure 4.2.3 shows a labour bed used in Atutur hospital. It has a hydraulic mechanism for raining it up or lowering it down. It is made out of cast iron, stainless steel and aluminium alloys. Due to the difficulties in their maintenance, the hospital now has only two beds functioning while others are broken down

Figure 4.2.4: Volker hospital bed
Source: Photograph by the Researcher, 2018

Figure 4.2.4 shows a Volker hospital bed with the necessary functions that supports the ideal patient care and comfort. It has leg and back rests, wheels, side safety rails and bed resting platform. The bed is imported expensively and the materials used for making it are not readily available for replacement and maintenance

Figure 4.2.5: Paediatric hospital bed
Source: Photograph by the Researcher, 2018

Figure ... shows a paediatric ward bed with stainless frame, side rails and attached wheels. Like other beds of this stainless materials, Atutur hospital has got difficulties in repair and maintenance of these beds abd this, has led to the hospital losing so many beds. Coupled with he government system of disposing off of items, the hospital has failed to attract the public from procuring these beds and this has left the beds occupying a lot of space in the wards

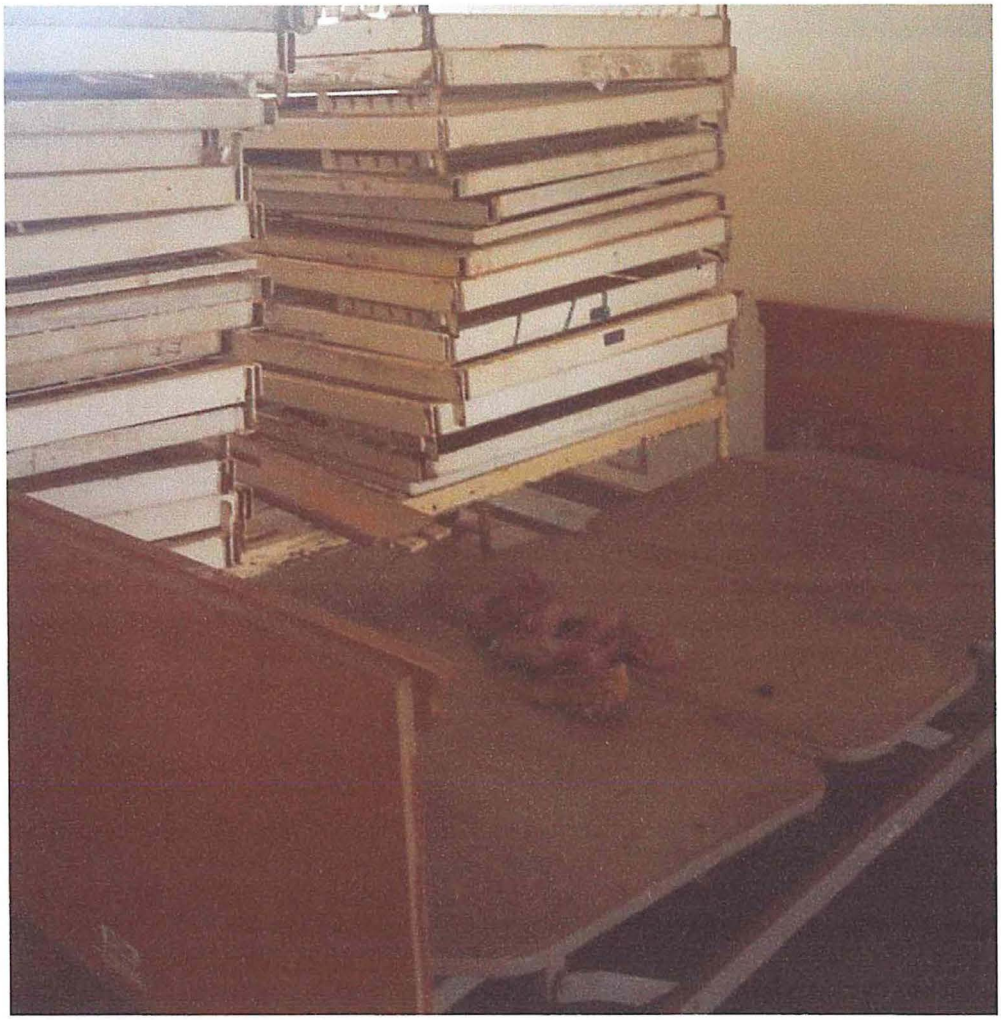


Figure 4.2.6: A hip of broken hospital ward beds.
Source: Photograph by the Researcher, 2018

Figure 4.2.6 shows a section of broken and hipped stainless steel beds parked at one of the corners in female ward. When the patients and their attendants were asked which design of bed was more comfortable for caring for the sick and why? This question made the respondents to point at particular bed designs that were visible to them in the ward. The beds used in general wards, differ in design. More than three quarters of the respondents said that the beds facilitating the raising and supporting of the patients back and legs are very few, leaving them with many traditional plain beds that make them struggle to change the positions of the patient in need by hand lifting and manipulation. That this is a bad experience they undergo but that they have no control over it.

4.3. Effects of the low bed-patient ratio in health facilities

A general ward is a common hall found in a health facility that occupies more than three beds for patients admitted. This is meant to enable the health providers attend to the sick and monitor their progress into quick recovery. A ward bed in this case, refers to the actual bed, or the amount of space in a health care facility that can occupy actual beds, as the capacity for the number of patients at the facility is measured in available space/ beds. The type of bed a patient lies on, contributes to ones physical, mental and emotional comfort there by leading to a quick recovery. A well designed bed also enables the care givers, the medical staff to easily help the patient when in need.

When the medical staff, patients and attendants were asked about the availability of the ward beds for patients and their attendants, more than half of them said that the beds are not enough in the hospital. They added that the most affected wards are paediatric and maternity wards. The only ward that does not experience congestion in this hospital is the male ward. They added that during the months of April to October every year, one may not have where to step his/her foot in the wards. They attributed it as a period when the rains are regular, the water bodies are full, and the bushes are grown, leading to spread of malaria, water borne diseases caused by flooding in many parts of Teso sub region. That the malaria parasite spreading mosquito, breads in high rate during this period hence biting the population and causing the rise of malaria infections particularly among children and their mothers.

When participants were asked whether there are cases when patients are admitted in the wards but stay without beds, more than half of the patients, attendants and medical staff respondents said such cases are common especially during the month of May, June, July, August, September and October each year. These patients in wards without beds end up sleeping on the floor as shown in figure 4.3.1.

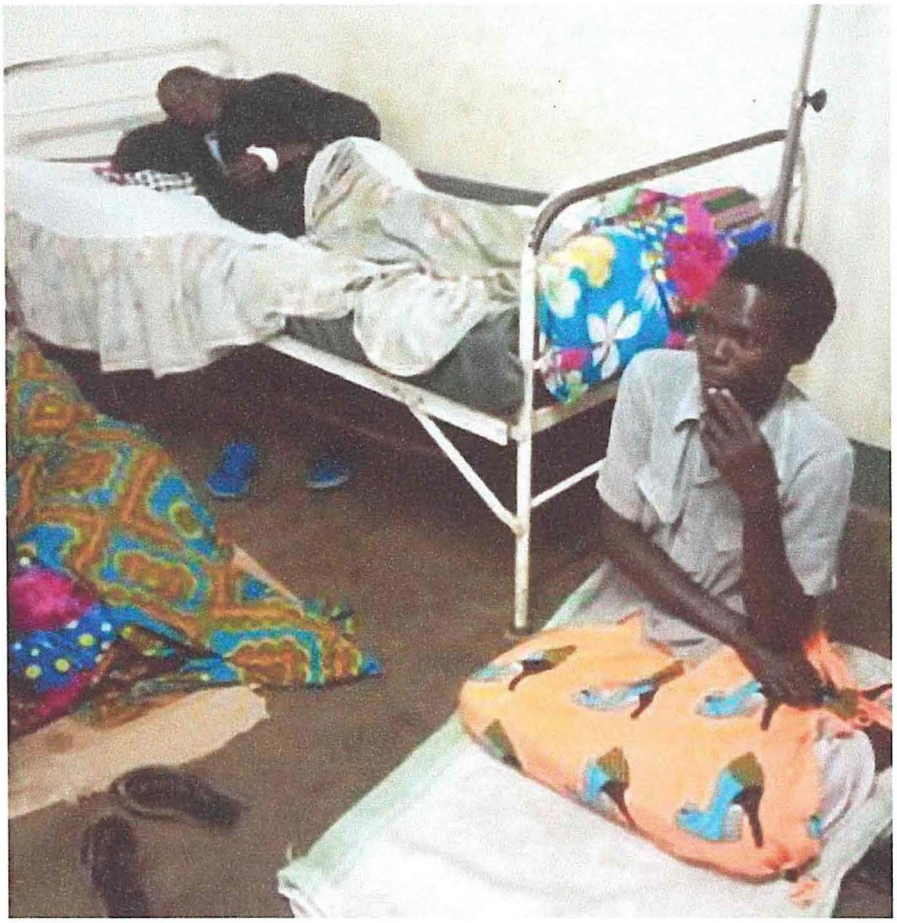


Figure 4.3.1: A section of patients lying on the floor in the male ward at Atutur Hospital

Source: Photograph by the Researcher, 2018

Figure 4.3.1 above shows a patient lying on the floor of the male ward; some lucky patients were on the bed, while some patients with their attendants sat on the ward floor and in between the two rows of the beds in the ward. The person seating in figure 4.3.1, is one of the care givers to the patient on the bed. The space occupied by the patient lying down in figure 4.3.1, was provided for as a working area for the medical staff and the attendants/care givers. According to the patients and attendants seating and lying on the ward floors, the situation is inhuman. Patients and their attendants leave their homes with the hope of getting beds and mattresses on but end up sleeping on the floors. The absence of beds and mattresses forces them to lay polythene sheets on the ward floor as a bed and sleep. That the ward floors worsen the conditions of the sick. The ratio of beds to patients is a worldwide

phenomenon, as defined by Zaman (2005) that beds are private places which become a public place in a general ward.

According to the patients and attendants interviewed in the paediatric ward, they admitted that some children are laid on the same bed. This situation has accelerated the infection of communicable diseases to take place in the ward among the children sharing the same bed and sometimes those lying on the floor and those on the bed because of overcrowding. This findings correlates with Mubangizi (2014) in regard to Mbarara Regional Referral Hospital. According to Bronwen (2014) lack of hospital beds in Fort portal Regional Referral Hospital, has exposed patients to dust, pollution in the air and the ground causing infections that have resulted into complications among the expectant mothers. According to Dilani (2015), the quality and nature of a patient's environment supports improvement and quick recovery.

When the medical staffs were asked what is being done to protect the patients in the wards and sleeping on the floors from infections, they said that regular maintenance of hygiene using disinfectants is carried out in the wards. When patients and their attendants were asked how they keep hygiene in the wards, more than half of them said that the hospital cleaners do clean the wards and compound every morning. The researcher witnessed the cleaning of the wards using disinfectants every morning by the hospital staff but also observed that although the wards are cleaned every morning, due to the large turn up of patients and their attendants moving in and out of the wards, the ward floors become unclean and infectious. The researcher also observed that due to the huge number of patients and attendants in the wards, the available beds are arranged near to each other and their luggage occupies some space as well making it impossible for the hospital staff to clean every part and corner of the ward. This situation leaves the patients and their attendants vulnerable to floor and other infections.

This situation is not only in Atutur Hospital in other Referral hospitals. In September 2017, the researcher conducted a situational analysis at Mulago National Referral hospital Annex Kawempe to have a feel of what he intended to study. On arrival in the hospital compound and without asking anyone a question, the researcher just came closer to a crowd of people

outside, only to realise that they were patients and their attendants under the veranda of a building. The majority of women were expectant mothers, some lying on the floor while others standing. Inside maternity ward full of expectant mothers on beds close to each other as shown in figure 4.3.2

Figure 4.3.2: A section of the patients at Mulago National referral hospital Annex Kawempe.

Source: Photograph by the Researcher, 2017

When patients and their attendants were asked how they protect themselves from mosquito bites that cause malaria, more than three quarters of the respondents lamented that there are no provisions for hanging mosquito nets in the wards. They said that this condition has kept the patients in the hospital for longer days than normal because some patients and their attendants are bitten by malaria causing mosquitoes during day and night, leaving them infected with malaria. That some patients normally come back within a week. Generally, health facilities require beds with improved functions.

4.4: Designing low cost bed for general ward use

This section presents the design process followed in making of the low cost general ward bed as inspired by the Loxodonta (An African Elephant).

4.4.1: Inspirational object: Loxodonta.

A Loxodonta is an African elephant, known for its robust body, strength and resistance to all weather. It is an inspirational object for the design of a low cost general ward bed because Loxodonta's are dominantly found in Africa. A Loxodonta low cost bed is designed to meet the developing needs of African countries. An elephant lives for many years and this bed is also expected to be used for many years since it's purchase price, repair and maintenance cost are considerably low. Figure 4.4 shows a Loxodonta.

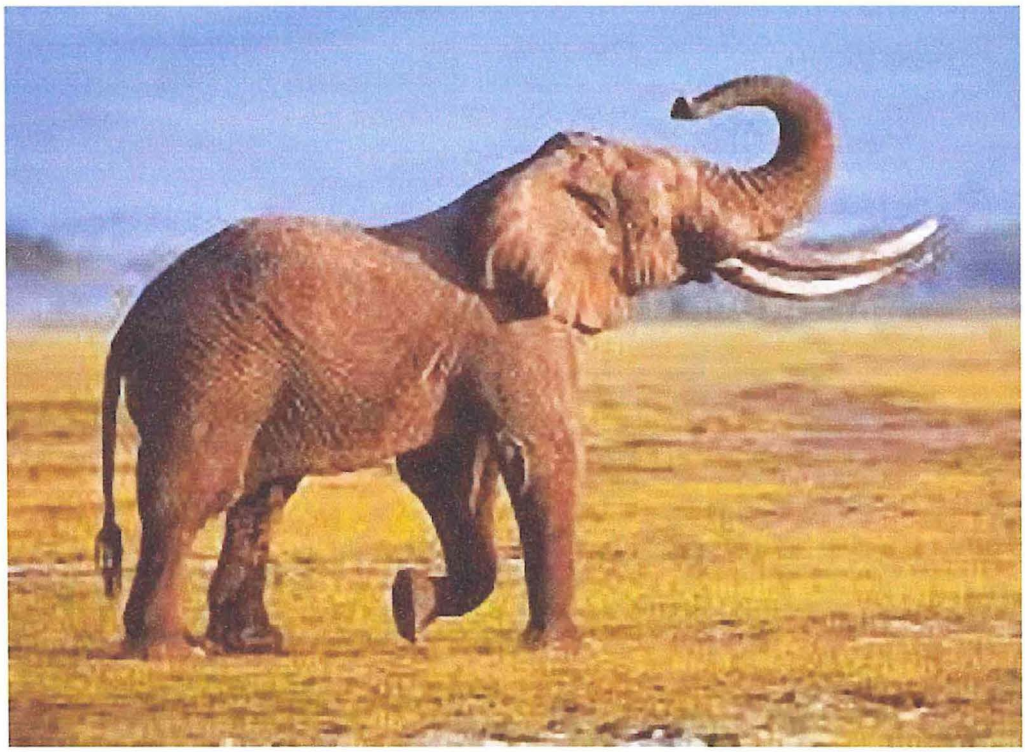


Figure 4.4. An Inspirational Object - a Loxodonta (an African Elephant).
Source: Google-Internet, 2018

4.4.2: Developing sketches from the source of inspiration.

The design ideas were made real in the form of sketches and adjustments for improvements made later. The different parts of the bed were developed from a Loxodonta body parts as a source of inspiration. The rear body of the Loxodonta as viewed directly from the side

inspired the design of the rear stands of the bed. The front body of the Loxodonta together with the trunk as viewed directly from the side inspired the design of the front stands of the bed. Figure 4.4.1 below shows the design concepts in a sketch form as sectional parts of the Loxodonta.

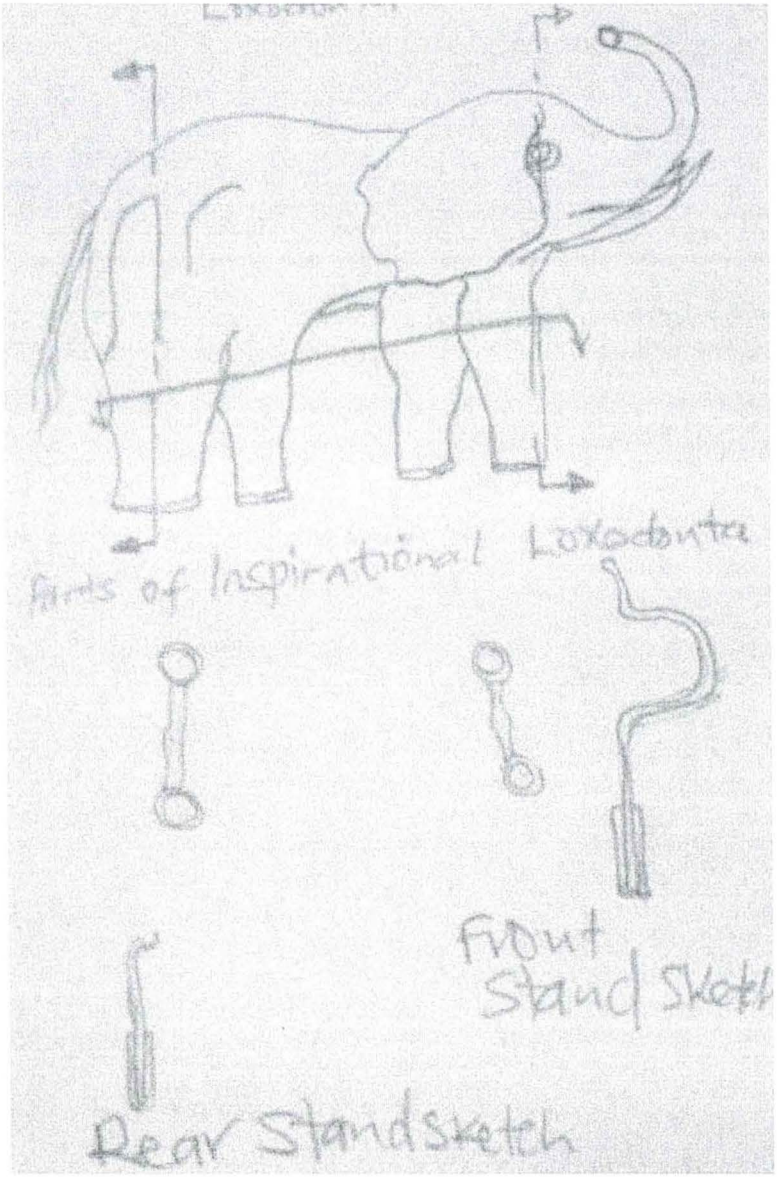


Figure 4.4.1 Design concepts in a sketch form as sectional parts of the Loxodonta.
Source: Researcher, 2018

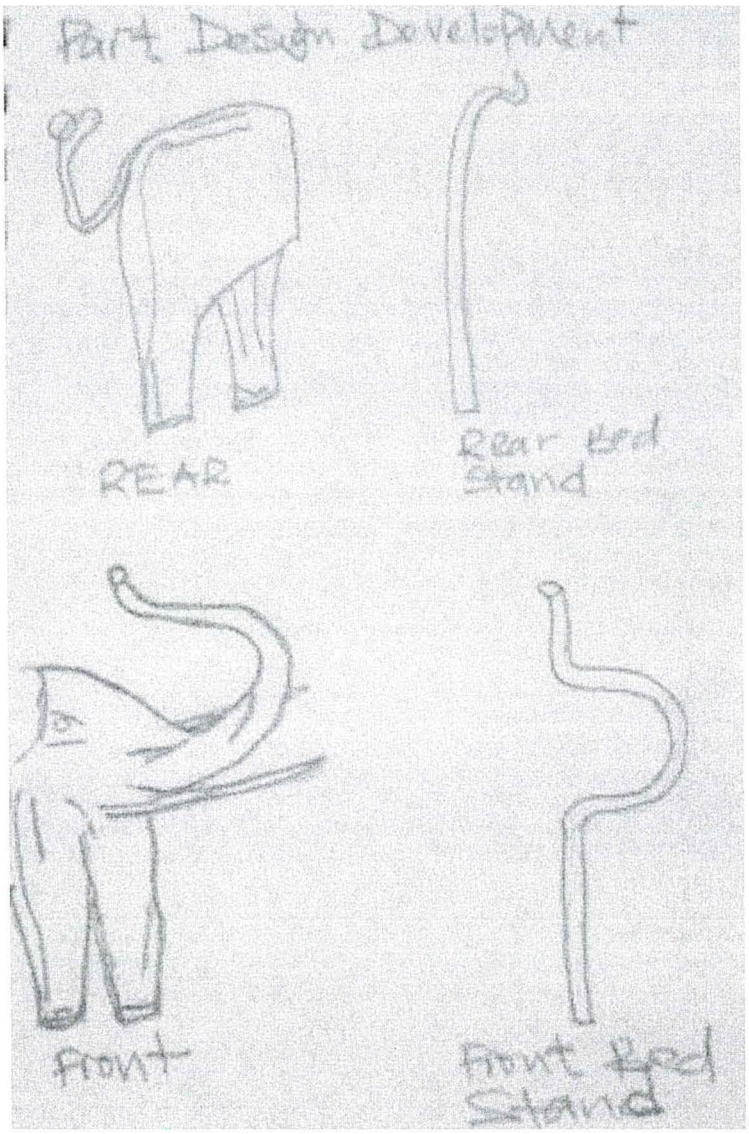


Figure 4.4.2 Design sketches of the Loxodonta bed front and rear stands
Source: Researcher, 2018

Figure 4.4.2 shows the design sketches of the bed front and rear stands as inspired by the rear and front side outlooks of the Loxodonta. The design shall have two rear and two front stands. In between the rear and front stands is designed with a soft surface to limit injuries to the occupants head and legs if unconscious.

The ears of the Loxodonta used for sensing sound, cooling the body when there is excess heat, inspired the design of the safety rails of the bed. The safety rails are designed and

attached to the two longitudinal sides of the bed with provision of being lowered or raised. The safety rails shall always be lowered and only raised when the medical staff or care giver, also known as the attendants realize that there is need to safe guard the bed occupant from any likely danger of falling off the bed due to certain conditions. Figure 4.4.3 shows the design development of the safety guard rails as attached to the bed frame

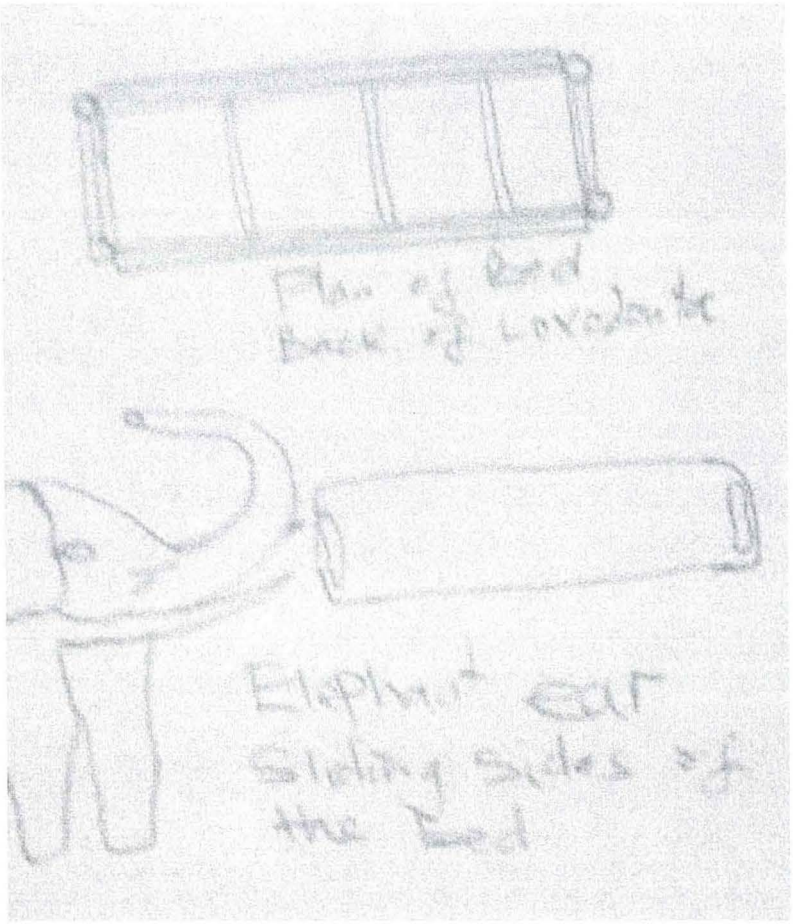


Figure 4.4.3 design sketches of the Loxodonta ear and bed safety rail
Source: Researcher, 2018

The safety rails are designed with soft surfaces on either side to guarantee protection of the occupant against any knocks. Figure 4.4.4 shows the pictorial sketch of the assembled Loxodonta

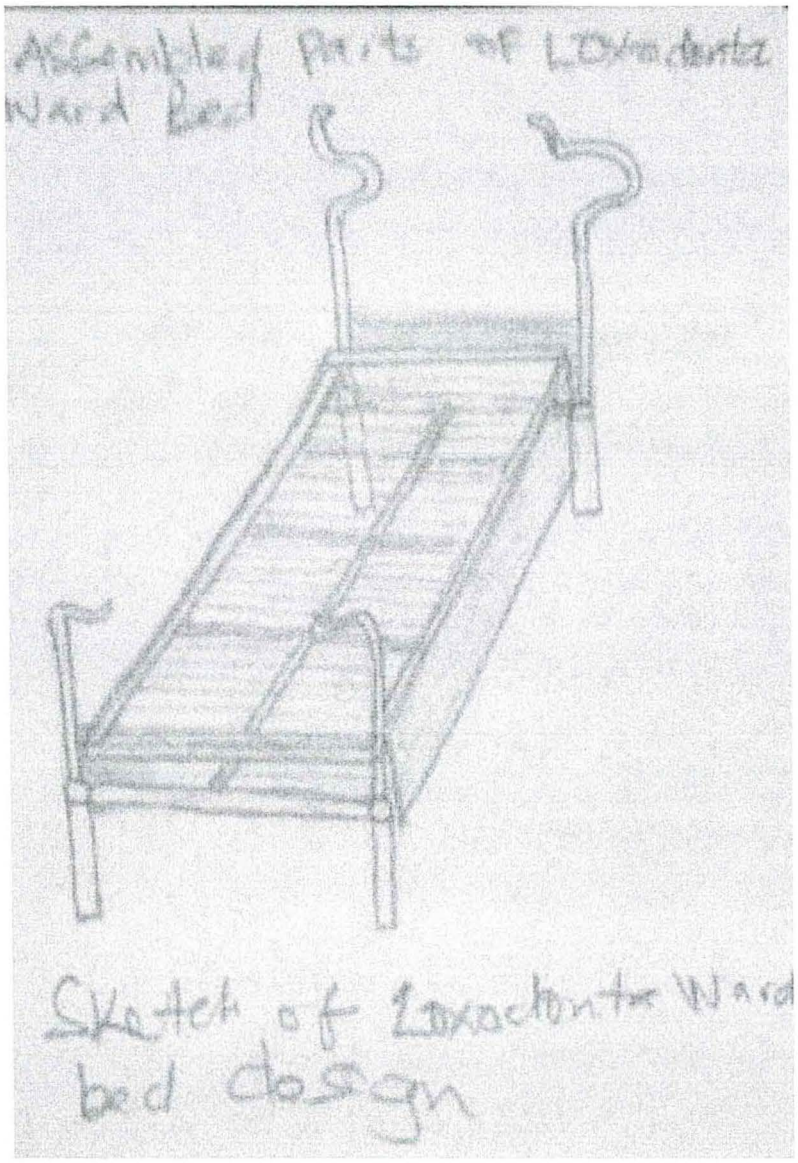


Figure 4.4.4 Pictorial sketches of the assembled Loxodonta bed
Source: Researcher, 2018

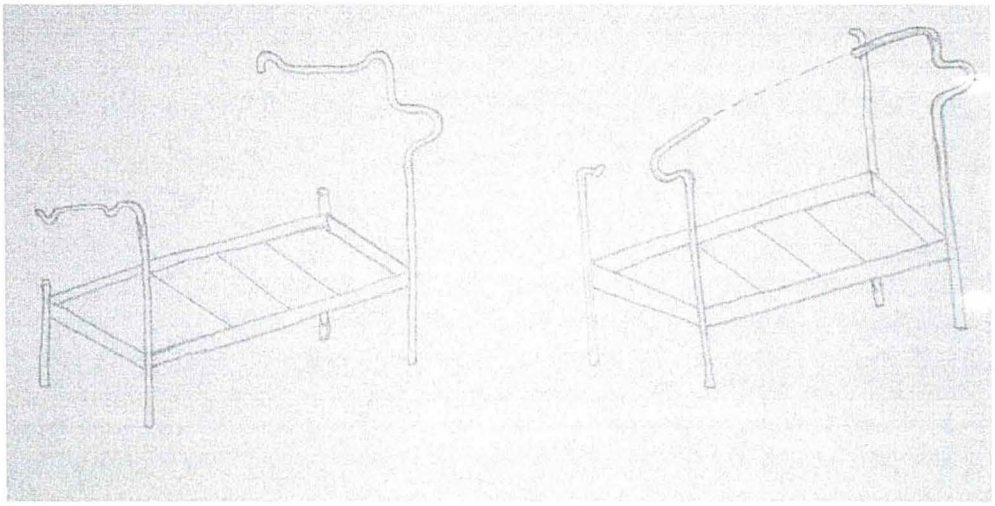


Figure 4.4.5 Alternative 3D design sketches of the assembled Loxodonta bed
Source: Researcher, 2018

4.4.3: Material used for making the low cost general ward bed.

According to the in charge hospital equipment the common material used in hospital bed was metal. He also noted that mild steel is among other materials being used for the manufacture of general ward beds. That the beds made out of mild steel are strong and durable but require regular repainting to overcome the effect of acid and rusting. That most of the beds in the wards are made of mild steel materials. Those beds made out of stainless steel are strong and durable but that they are very expensively procured and therefore, few in the hospital. That ward beds with modern functions such as back, thigh and leg rests, adjustable sides, are procured at an average range between 2,400,000/= to 3,600,000 Uganda shillings each as of 2017 procurements and delivery notes for Atutur hospital. That the trends of illnesses seen on patients have become complex hence, requiring the beds with modern functions for intensive care services. He further described beds made out of stainless materials as being very difficult to repair and maintain since they require specialized welding which is not common. That many of such broken beds had never been repaired in the hospital for long, leading to the spoiled beds being hipped at the corners of the wards.

4.4.4: Details of the Loxodonta Low cost bed using Computer aided design

4.4.4.1 Bed Stands

The legs of a Loxodonta as shown in figure 4.4.5 on the bed design inspired the development of the bed stands. All the four bed stands have two sections; the lower base and upper part. The two hind stands depict the rear body shape of the Loxodonta while the two front stands did form the front legs and the trunk joined together. Since steel, is available in Uganda, all the four stands base sections are made out of galvanised cast iron steel of 30mm diameter and 320mm high, while the upper section are made out of 25 mm mild steel tube of 1.2 mm thick. All the four base stand sections are attached with wheels for the mobility of the bed. Because the legs help the animal move from one place to another slowly, the bed design is provided with wheels to facilitate the bed movement from one location to another. On the bed manufacturer manual and drawing, the stands are marked part number 1.

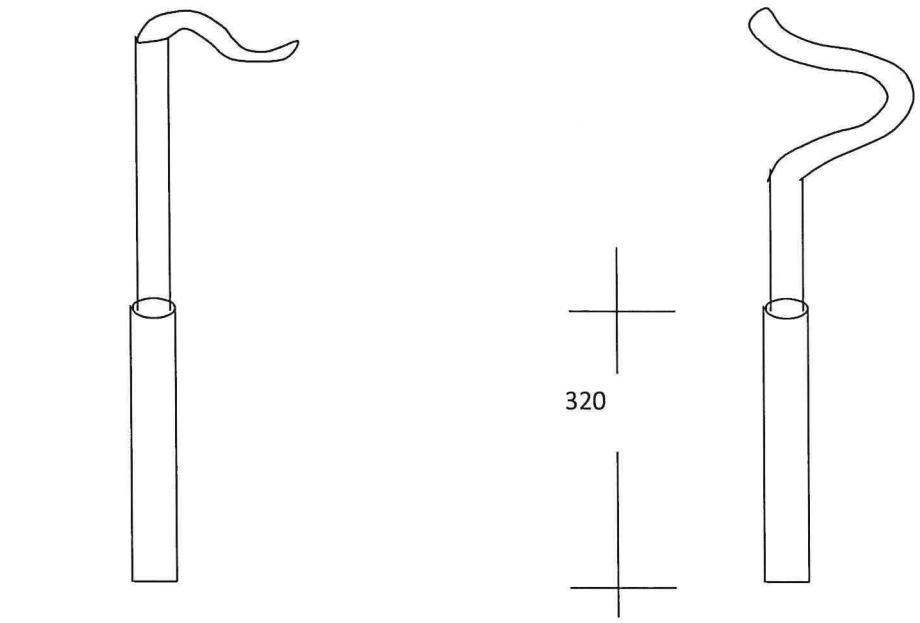


Figure 4.4.6 Design of front and hind bed stands.
Source: Sketch by the Researcher, 2018

4.4.4.2 Primary stand connectors

The connectors are designed and made out of mild steel hollow sections measuring 40mm x 25mm and 3mm thick material. The connectors are two in number welded between each two base stands of the bed. The connectors give the required stability to the bed and do carry other parts of the Loxodonta bed. The connectors as shown in figure 4.4.7 receive all bed upper loads and distribute them onto the stands. As the muscular system is to a Loxodonta, so are the two connectors to the Loxodonta ward bed. They are 710mm long beach and fabricated permanently onto the Loxodonta bed stands using arc welding. On the bed design manufacturers' manual, connectors are marked part number 2.

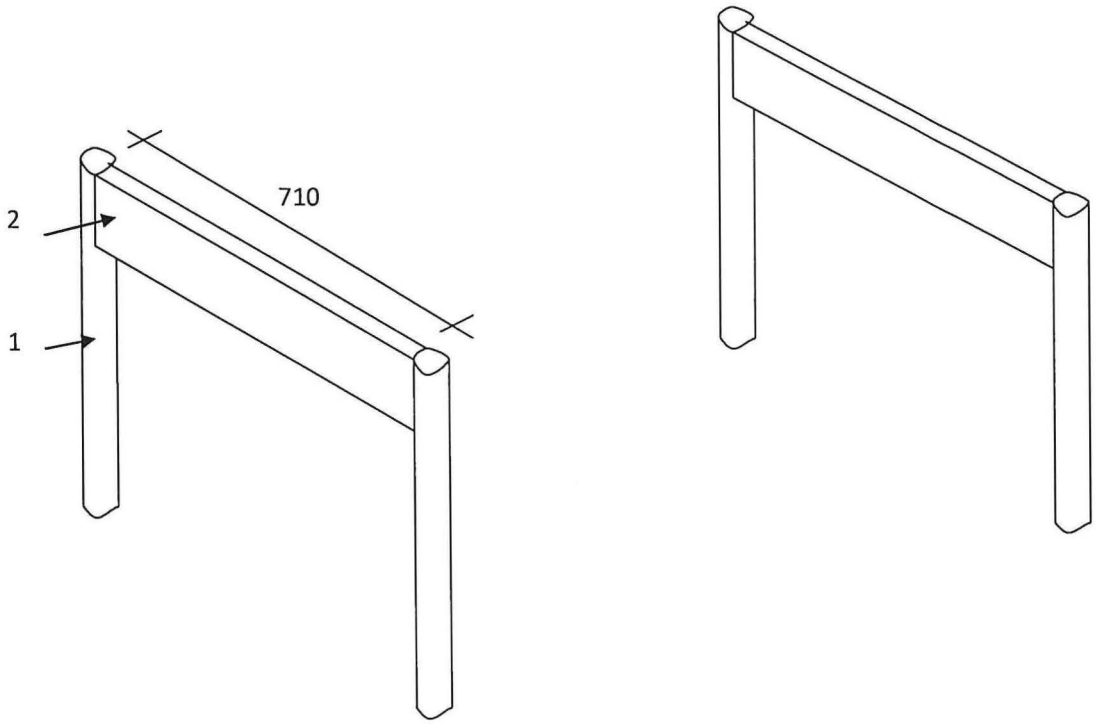


Figure 4.4.7: Design of two bed stand connectors
Source: Drawing by the Researcher, 2018

4.4.4.3 Primary load Bearing Beam

The Loxodonta primary load bearing beam is 40mm x 24mm and 3mm thick mild steel hollow section. Figure 4.4.8 shows the design as inspired by the Loxodonta back bone used to keep an African Elephant strong and manipulative. The Loxodonta primary load bearing beam is welded on the two bed connectors attached to the stands. The design loads are received by the primary beam and later distributed onto the stands through the connectors. The Loxodonta primary load bearing beam is marked part number 3 on the design manual and specifications.

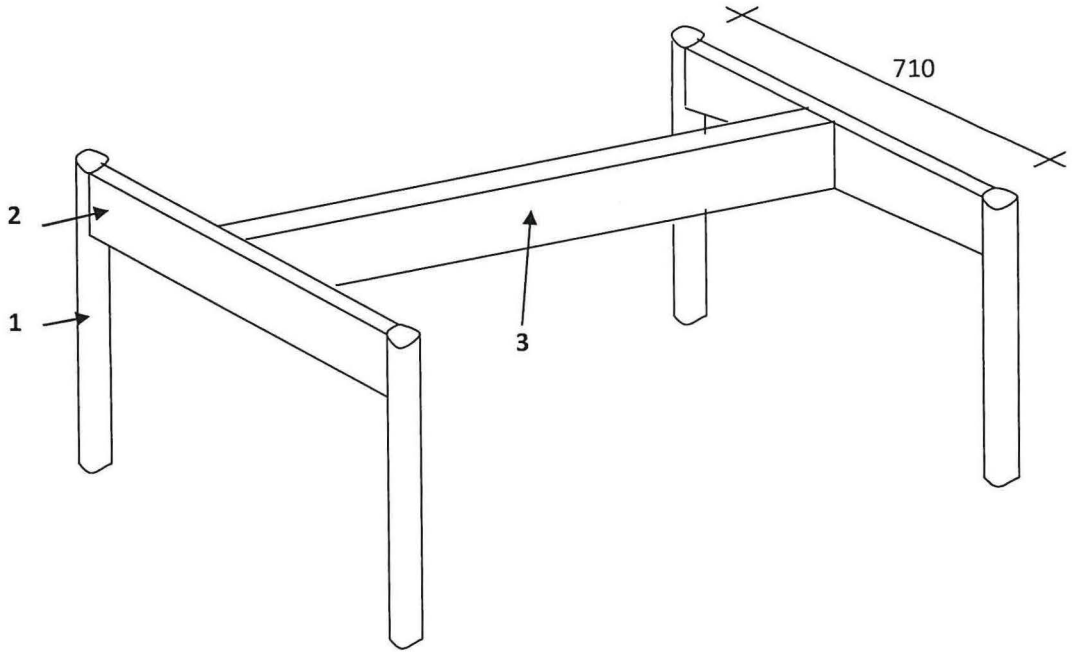


Figure 4.4.8. Design of the primary load bearing beam
Source: Drawing by the Researcher, 2018

4.4.4.4 Mechanical crew Jack

Mechanical crew Jack is equipment used for lifting loads of vehicles and other industrial loads. It is used in this design of a Loxodonta low cost ward bed to facilitate bed height adjustments. The lowering and height lifting mechanism allows the bed to be used by normal patients, weak patients, patients with special needs and can be used by mothers in labour during emergency situations when other labour beds are pre-occupied. Figure 4.4.8 shows jack that does not require any prior experience to use or operate. When the lifting mechanism is adjusted fully, the bed is raised to about 250mm high from the normal bed height of 500mm, making the bed platform to be at a total height 750mm above the floor level. When not adjusted to any height, the Mechanical crew Jack is about 360mm long and 100mm high. The jack can safely carry up to 3000 kilograms. To guarantee the safety of beds occupants being lifted up by the jack, a majority of patients weighs between 5 - 150 kilograms. It implies that the weight of the bed occupants is negligible to the screw jack. On the designer's manufacturers manual, the mechanical screw jack is marked part number 4.

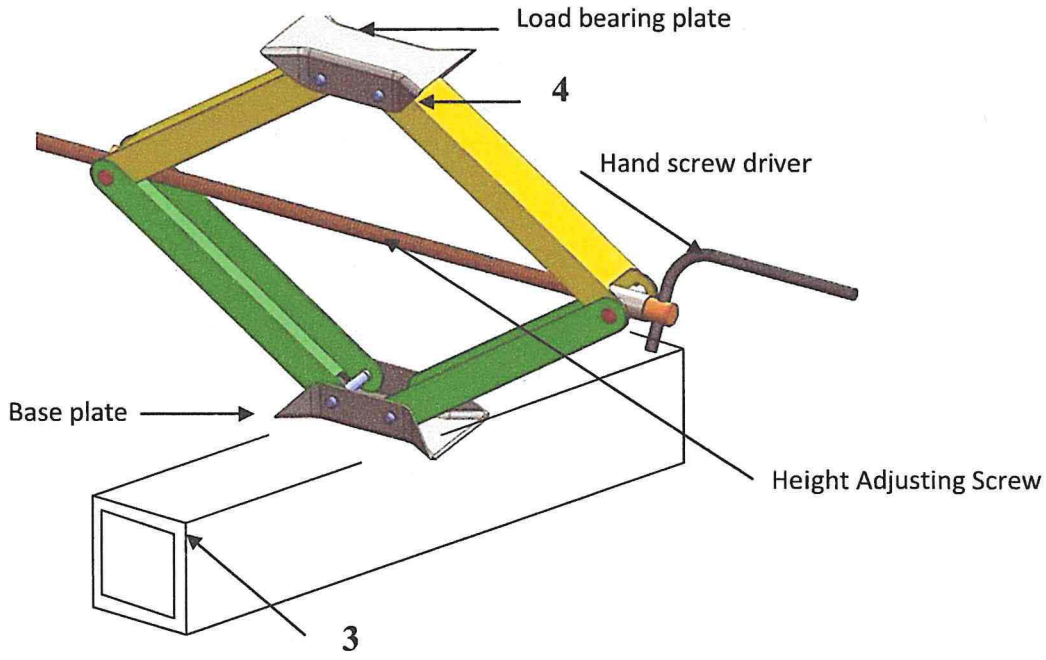


Figure 4.4.9. Design of the mechanical crew Jack
Source: Drawing by the Researcher, 2018

4.4.4.5 The Bolt and Nut Flat Bar

The flat bar is 100mm x 40mm x 6mm mild steel fabricated on the mechanical screw jack load bearing plate. It is attached with two screw nuts which are designed to connect the secondary beam onto the primary beam. It is upon this nut flat bar that the upper parts of the Loxodonta ward bed can be detached from the lower part of the bed, making it easy to transport or relocate the bed when necessary. These detachment functions, makes the design of the Loxodonta bed user friendly. The bolt and nut flat bar is marked part number 5 on the manufacturers manual and drawing. Figure 4.4.10 shows the bolt and nut plate

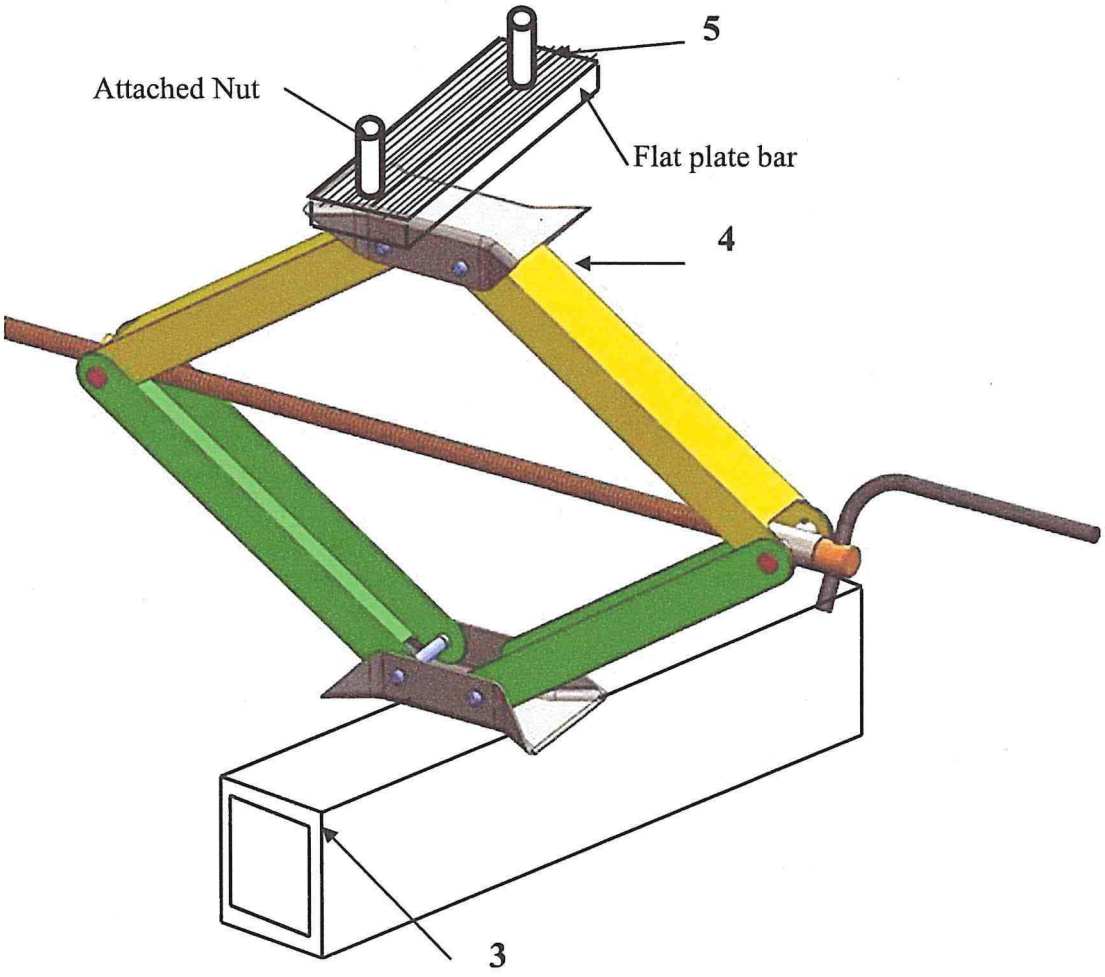


Figure 4.4.10. Design of the bolt and nut holding flat bar mounted on mechanical crew Jack

Source: Drawing by the Researcher, 2018

4.4.4.6 Loxodonta Secondary load bearing beam and Frame

The secondary load bearing beam is fabricated together with the frame. It is 1560mm x 40mm x 25mm of a mild steel hollow section with 3mm thickness. It has two 13mm diameter holes at its centre that are used to connect the frame members of the bed with the stands. The bed rest partitions are all attached to the frame and above the secondary beam. Figure 4.4.11 shows the frame together with the bed rests portions, giving the required support to the bed, hence guaranteeing the bed stability by receiving the upper loads and transferring them onto the primary beam through the bolt and nut flat bars permanently welded on the mechanical screw jack. The bed rest partitions measure 40mm x 20mm and are 3mm thick mild steel materials. While secondary load bearing beam is marked number 6 on the manufacturers' manual, the Loxodonta bed frame is marked part number 7.

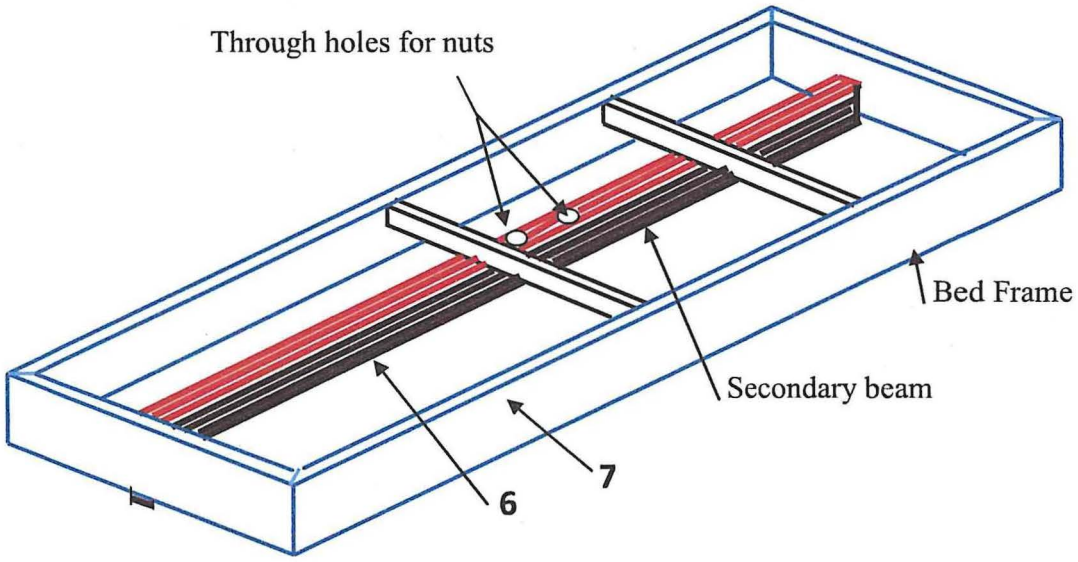
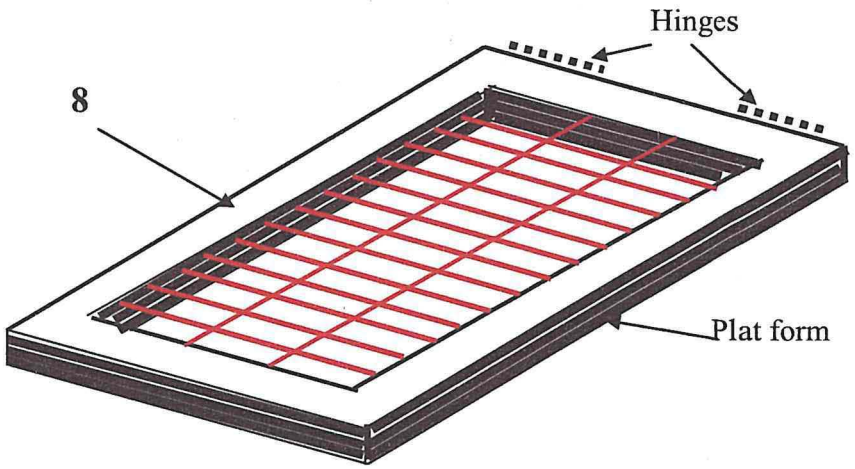


Figure 4.4.11. Design of the secondary load bearing beam and frame
Source: Drawing by the Researcher, 2018

4.4.4.7 The Back Rest sub frame

The back rest sub-frame is part of the front sections of the Loxodonta ward bed provided with a mechanical screw lever manually operated to facilitate the lifting of the patients back when required without physically handling the patient. Figure 4.4.12 shows the back rest system designed to allow rotation from 0^{o}-75^{o} inclining angles. The back rest sub frame measures 710mm x 500mm and it is made out of 20mm x 20mm mild steel hollow sections of 1.5mm thickness. The inspirational object is the Loxodonta. The way the Loxodonta has capabilities to lower itself on the ground and in turn lift itself up when eating, swimming, bathing and during any other movement manoeuvres, is the same mechanism the back rest sub frame does. The back rest sub frame is connected to the partitioning pieces using the two hinges that are welded on both sides and are provided with a 8mm diameter round bar network as a platform to give the base for the incoming foam. The back rest sub frame is marked part number 8 on the manufacturers' manual



Source: Drawing by the Researcher, 2018

Figure 4.4.12. Design of the back rest sub-frame

4.4.4.8 Thigh and Leg Rest frames

These are a two in one sub frame designed for the rear section of the bed. Like for the back rest, figure 4.4.13 shows the thigh and leg rests, designed with a mechanical screw lever manually operated to facilitate the lifting of the patient's thighs and legs when required without physically handling the patient. The thigh and leg rests add the function of a modern bed on the Loxodonta bed. It measures 650mm x 710mm, made out of mild steel of 20mm x 20mm, 1.5mm thick. These functions make the bed more comfortable to its occupants. The thigh and leg rests sub frames are connected to the partitioning piece using the two hinges that are welded on both sides and are provided with a 8mm diameter round bar network as a platform to give the base for the incoming foam. The thigh and leg rests sub frames are marked part number 9 on the manufacturers' manual

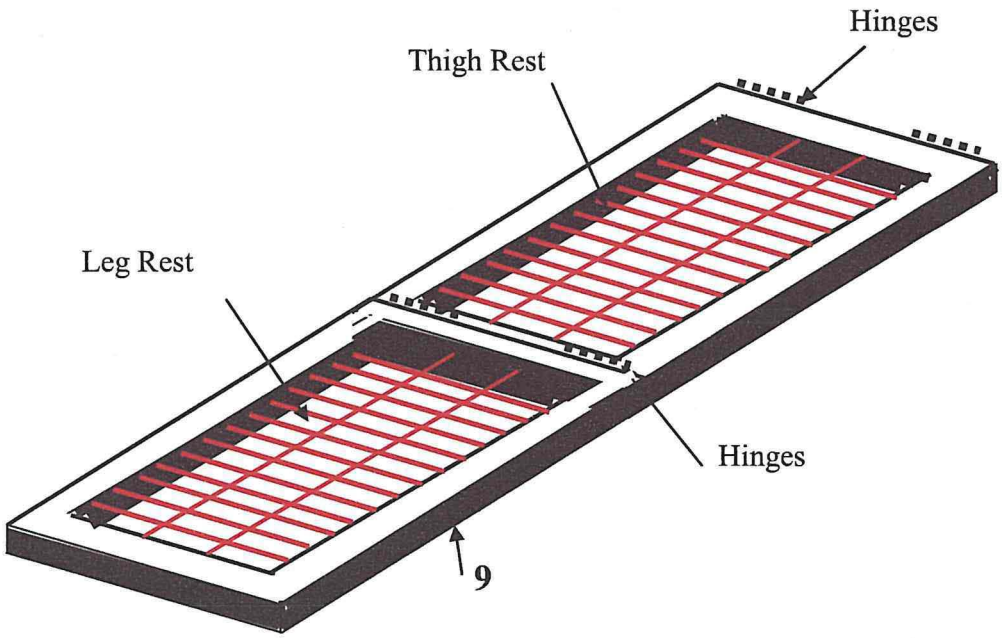


Figure 4.4.13. Design of the thigh and leg rest sub-frame
Source: Drawing by the Researcher, 2018

4.4.4.9 Safety guard rails

Ears are used by the Loxodonta to aid the sense of hearing and direction. The ears are used in design for the development of sliding safety guard rails. Figure 4.4.14 shows the safety rails designed to give the bed occupants the required safety and comfort, just like the animal uses them to cool its body when it's hot. When the guard rail is not in use, the occupants shall slide it down such that it is aligned to the bed frame. When it is in use, the rail is moved upwards such that it encloses the side of the bed hence, providing the safety against falling off the bed. The safety guard rail is marked part number 10 on the manufacturers' manual. The rails are provided with the adjustable permanent bolt and nut that can easily be secured by hand force

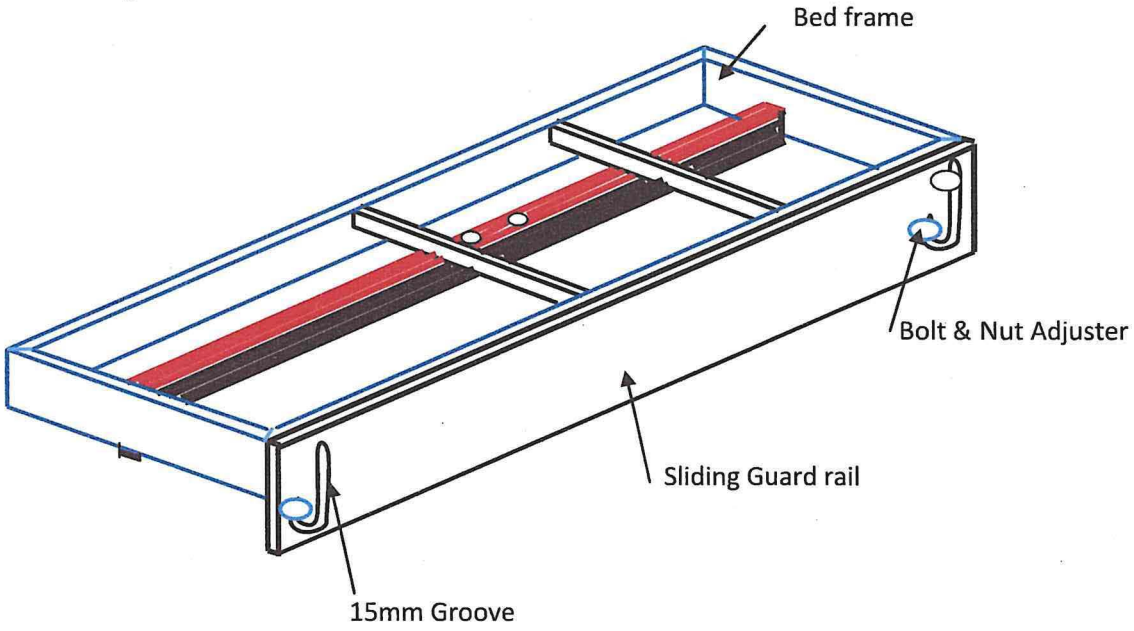


Figure 4.4.14: Design of bed safety guard rails
Source: Drawing by the Researcher, 2018

4.4.4.10 Stand bends

The Loxodonta uses its trunk for self protection against any attack from a predator. It is also used for drinking the water, cleaning the body, pulling down high tree leaves into the mouth as food. Figure 4.4.15 shows the two upper bed stands designed to give the bed mosquito net hanging provisions at the front and hind faces. This will protect the bed occupants from mosquito bites and in the modelling of the bed shape and outlook.

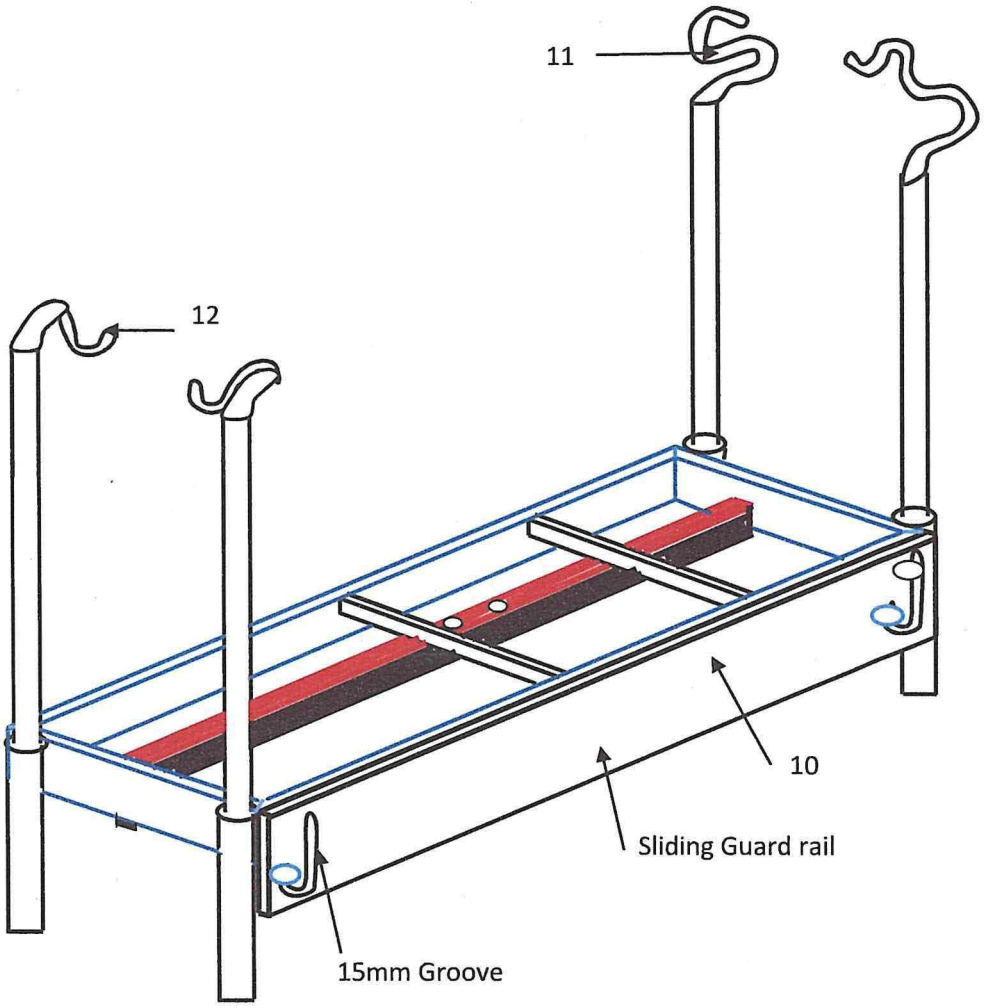


Figure 4.4.15 Design of the Front and Rear mosquito net hanging provisions.
Source: Researcher, 2018

4.4.4.11 Loxodonta tail

The African elephant tail is also used for clearing the back part of the body where the trunk does not reach. Predating birds, dirt etc, are easily cleared off the body using the tail. Figure 4.4.16 shows the curved design of the rear stands, inspired by the Loxodonta tail. It is made from mild steel round bar. The curving top ends of the hind stands can be wrapped with a cloth and used to support the legs of the mother in labour being helped to deliver. On the manufacturers' manual, the tail is marked part number 12

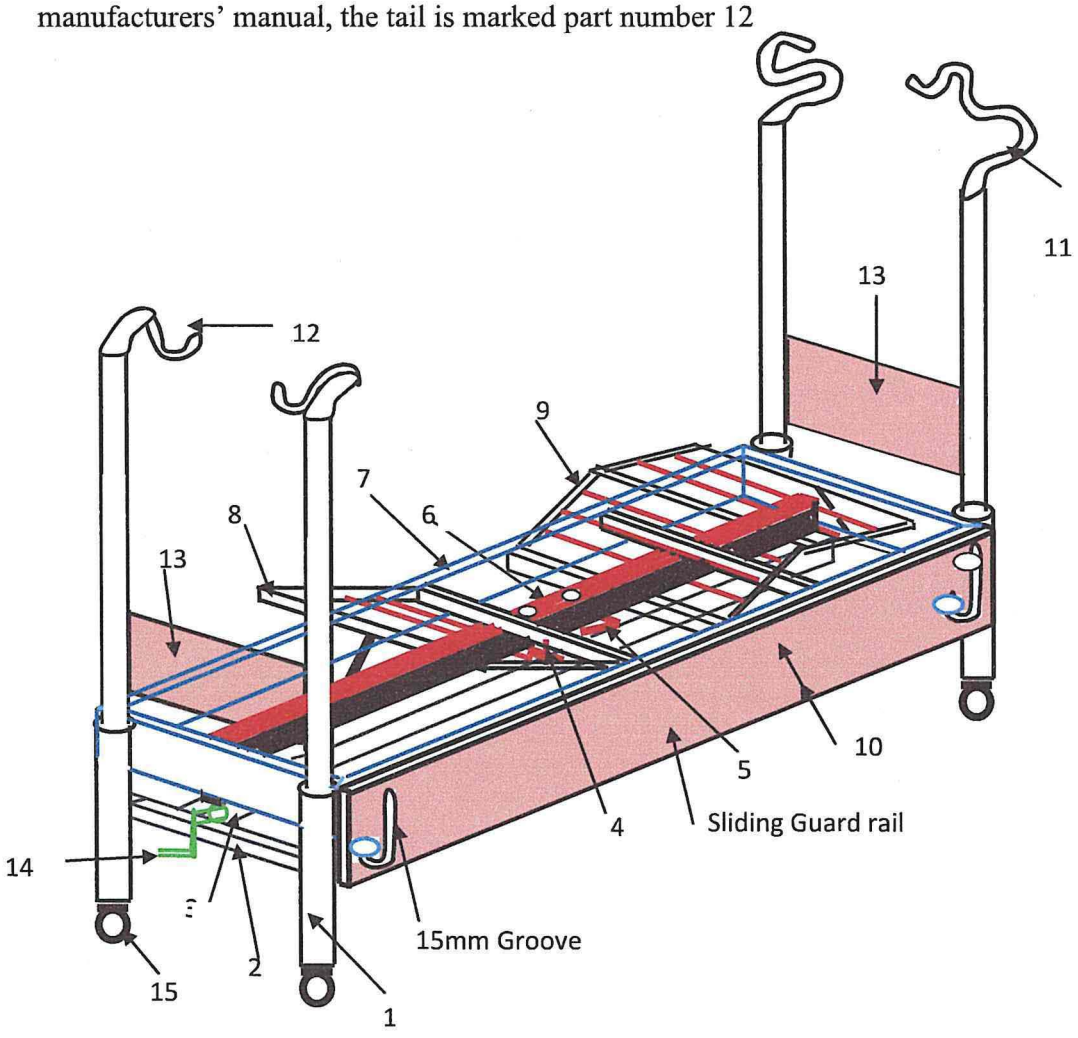


Figure 4.4.16 Design of the Front and Rear mosquito net hanging provisions.
Source: Researcher, 2018

4.4.4.12: Cost comparison of the Loxodonta bed with other bed designs found in the wards

When the in-charge hospital equipment was asked how much each of the beds in the hospital costs, he said the locally made plain ward bed is procured at an average of six hundred seventy five thousand Uganda shilling (675,000/=) and they are 51 working pieces in the wards. That the Fowler position beds are delivered at one million eight hundred thousand Uganda shillings (1,608,000/=) and they are 27 working pieces, while the Volker beds used in intensive care units are only 8 beds, procured at three million two hundred Uganda shillings (2,876,000/=). The working labour beds are 2 pieces, while the Paediatric beds are 28 pieces.

Table 1: shows the User's guide and estimated cost of the Loxodonta ward bed

Part No.	Quantity	Part Name	Function	Cost
1	4	Loxodonta bed stands	Raise the bed plat form to 500mm high	80000
2	2	Primary stand connectors	Connect hind and front stands together	12000
3	1	Primary load bearing beam	Connect the hind and front stands	35000
4	1	Mechanical screw jack	Lift the bed occupant when required	35000
5	1	Bolt and Nut flat bar	Connects primary and secondary beams	5000
6	1	Secondary load bearing beam	Distributes loads to primary beam	35000
7	1	Bed frame	Gives shape to the bed, carries loads	120000
8	1	Back rest sub frame	Facilitates lifting of bed occupants back	35000
9	1	Thigh and Leg rest sub frame	Facilitates lifting of occupants thighs and legs	45000
10	2	Safety bed rails	Give bed occupants protection and safety	150000

11	2	Front stand bends	Provide mosquito net, drip water and blood hanging	40000
12	2	Hind stand bends	Provide mosquito net, drip water and blood hanging and temporary leg holding during child birth or for fracture	40000
13	2	Front and rear guards	Give bed occupants protection and safety and add beauty	42000
14	2	Mechanical screw lever	Facilitating back, thigh and leg rests	32000
15	4	Bed wheels	Facilitate movement	60000
		Painting & Branding		120000
		Welding rods		42000
		Lubricants		13000
		Transport & communication		50000
		Labour		395000
		Total		**1386000**

Table 1: User's guide and estimated cost of the bed

Source: Researcher, 2018

Comparing the estimated cost of the locally designed and made adaptable low cost Loxodonta ward bed with the other bed designs found in Atutur hospital, the Loxodonta ward bed (1,386,000/=) is cheaper than both the Fowler position ward bed (1,608,000/=) and Volker ward bed (2,876,000/=). Also comparing the functionality of the Loxodonta ward bed with other beds designs, the Loxodonta becomes an ideal bed for Ugandan health facilities because it has all the functions of the Fowler position and Volker beds. Furthermore, the Loxodonta ward bed has the provision for the function of hanging drip water/blood and a mosquito net which are not found in the Fowler and Volker beds. The

materials used for making the Loxodonta ward bed are available in the local market, strong, easy to weld and fabricate using the available hydro powered arc welding, easy to manoeuvre, pain, and finish, hence making its maintenance costs low and sustainable

Table 2 shows the estimated costs of procuring the beds

SN	Bed Design	Materials Used	Main Functions	Source	Cost
1.	Plain bed	Mild steel, paint	Back rest	Local, Uganda	675000
2.	Fowler position	Mild steel, stainless, paint	Back rest, leg rest	India, China	1600000
3.	Volker	Stainless, alloys	Back rest, leg rest, work table lift, side rails	India, China	2876000
4.	Loxodonta	Cast iron, mild steel, paint	Back rest, leg rest, work table lift, side rails, mosquito net, drip water/blood hanging provisions.	Local, Uganda	1386000

Table 2: Comparison between Loxodonta and other beds of related designs

Source: Researcher, 2018

4.5: Prototype production of low cost general ward bed

This section presents the general outlook and actual design of the Loxodonta prototype ward bed with its functional parts as inspired by the Loxodonta (An African Elephant). It was as a result of analysing the available modern ward beds with basic functions and comparing them with the common plain traditional mild steel beds with back rests. Looking at the advantages and the disadvantages of these existing ward beds, the researcher has therefore designed and made prototype of a low cost general ward bed that integrates the functions of the modern imported beds into the low cost ward bed design using locally available materials. This will increase the beds in the hospitals with modern functions yet designed and fabricated using locally available materials such as mild steel, foam, wood blocks and paint among others, hence, reducing on the cost of general ward beds.

4.5.1: Working drawings

These are drawings made to scale and were used in preparing pieces to required dimensions, angles and tolerances. They include the detailed plan, side, front and rear elevations. They were produced with the aid of AutoCAD.

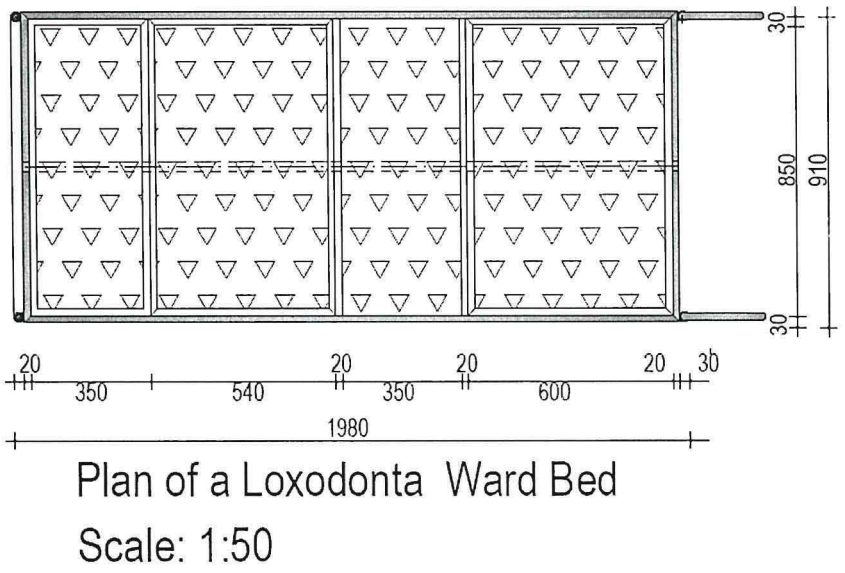
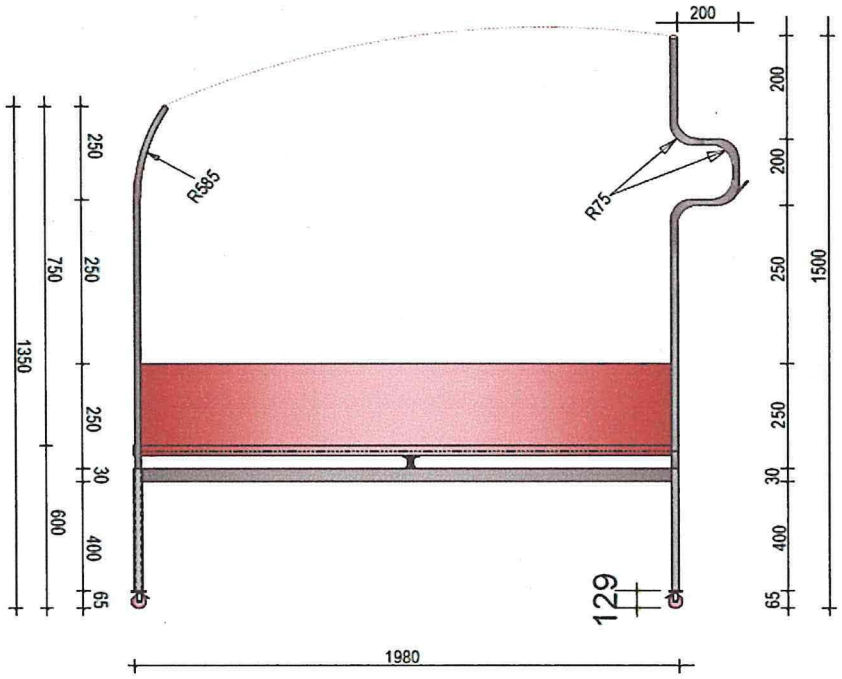


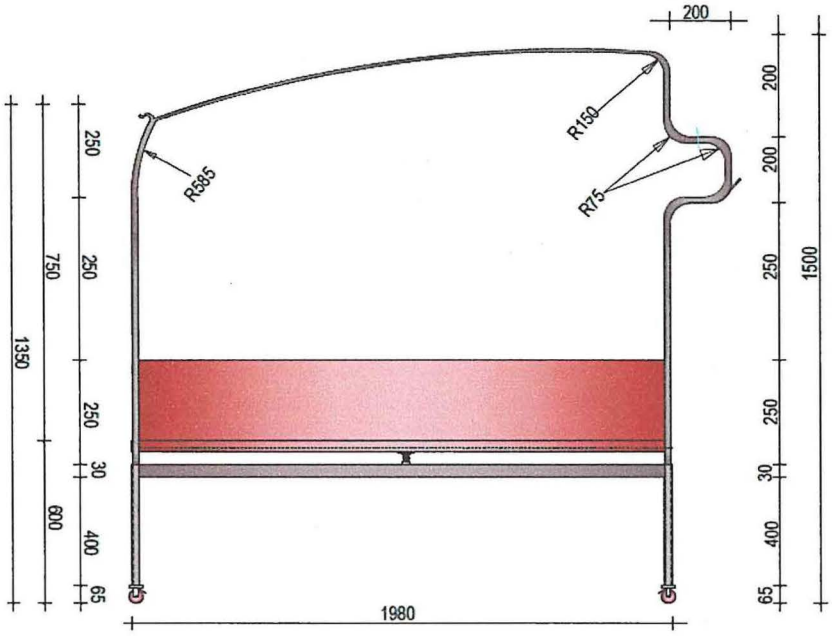
Figure 4.5.1 Plan of a Loxodonta ward bed.
Source: Drawing by the Researcher, 2018

Figure 4.5.1 shows the detailed plan of the bed with the overall dimension of 1980x910. The front part of the bed shows some extensions which are 200mm. The extension is where the curves of radius 75mm are attached forming the provision of holding drip water or blood



Side Elevation of a Loxodonta Ward Bed
Scale: 1:50

a) Source: Drawing by the Researcher, 2018



b) Source: Drawing by the Researcher, 2018

Figure 4.5.2 Alternative (a) and (b) Side Elevations of a Loxodonta ward bed.
Source: Drawings by the Researcher, 2018

Figure 4.5.2 shows the Alternative side views/elevations of the ward bed. All dimensions used for production of the prototype are readily provided for.

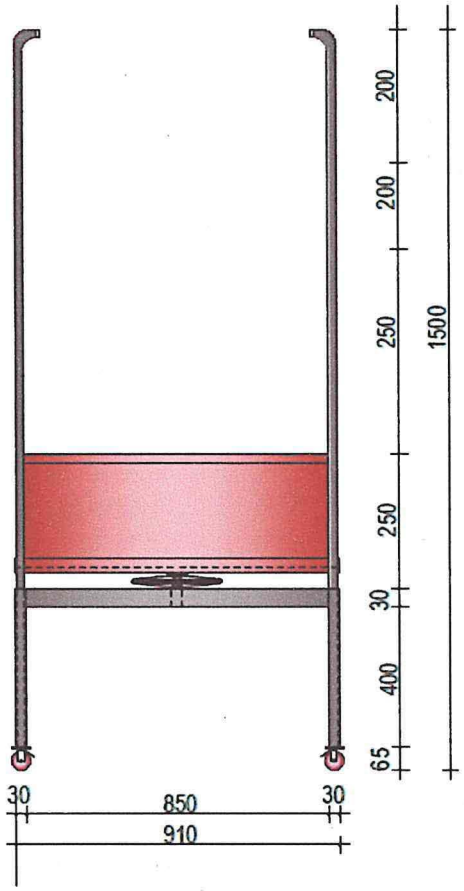


Figure 4.5.3 Front Elevation of a Loxodonta ward bed.
Source: Drawing by the Researcher, 2018

Figure 4.5.3 shows the front view/elevation of the bed with the required dimensions. Parts of the curves are not visible as they are viewed directly.

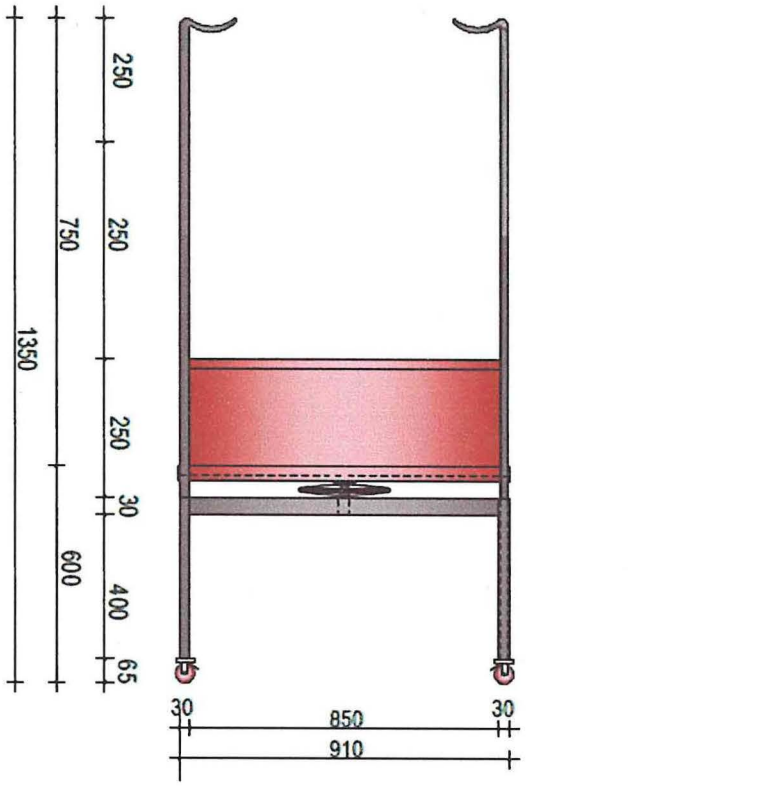


Figure 4.5.4 Rear Elevation of a Loxodonta ward bed.
Source: Drawing by the Researcher, 2018

Figure 4.5.4 shows the rear view/elevation of the Loxodonta ward bed. The required dimensions are also provided.

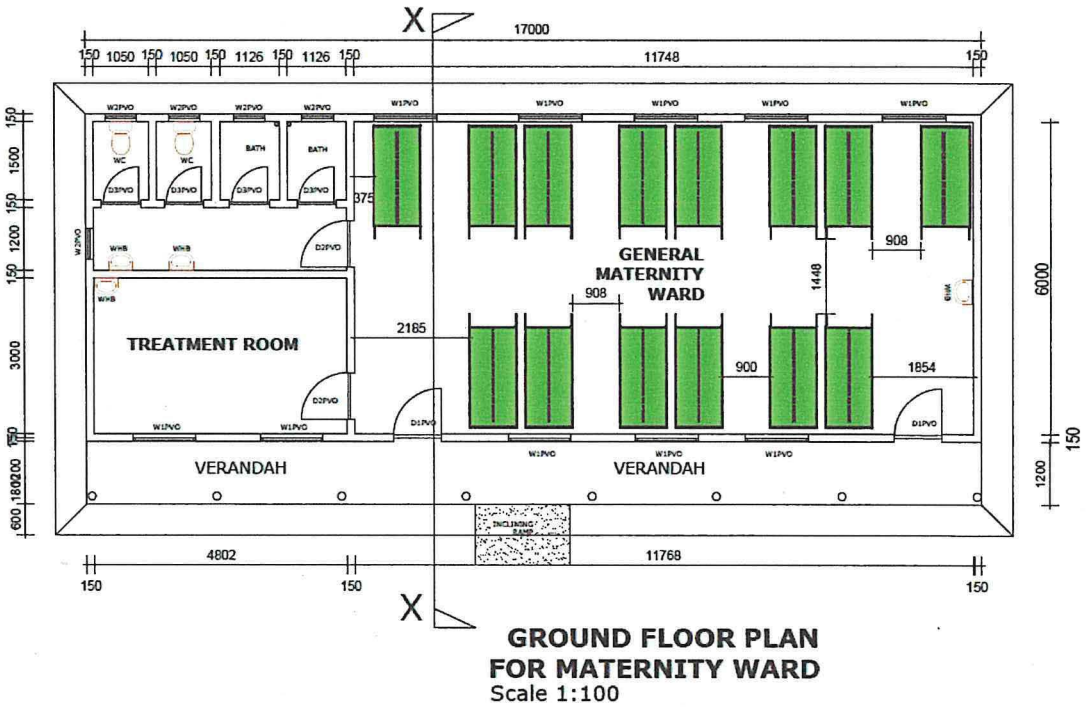


Figure 4.5.5 Proposed Ground Floor Plan of a Maternity ward.
Source: Drawing by the Researcher, 2018

Figure 4.5.5 shows a ground plan of a maternity ward indicating the positions of the Loxodonta ward bed. The ward hall is designed to accommodate 14 beds with a manoeuvring and escape space of 908mm in between the beds. The ward has two rows of beds with a space of 1448mm in between the rows. The ward is provided with a veranda where patients or their attendants may take a rest and relax at some point of the day.

Figure 4.5.6 shows the stands and platform frame of the bed being fabricated.

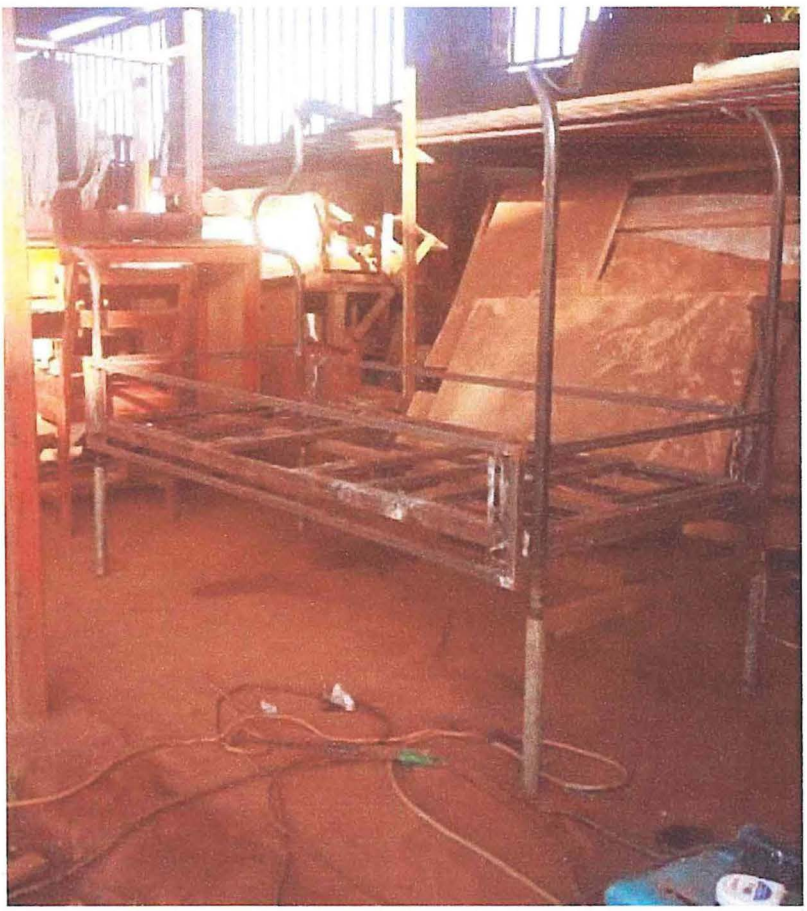


Figure 4.5.6 Bed stands and platform frame being fabricated.
Source: Photograph by the Researcher, 2018

Figure 4.5.6 shows the front and hind bed stands fabricated together with connectors while the primary beam is fabricated to connect the hind and front connectors together. Figure 4.5.7 shows the back and leg rests sub frames being fabricated onto the main frame of the Loxodonta. The mechanical screw that facilitates the lifting of the leg, thigh and back rests sub frames is also being fabricated onto the bed frame and attached to the secondary load bearing beam

Figure 4.5.7 Stands and adjustment leg, thigh and back rests frame.
Source: Photograph by the Researcher, 2018

Figure 4.5.8 shows the bed stand bases, connectors, primary beam and the mechanical screw jack being pre-coated to protect the bed from water, acids and improve on its outlooks. The base bed stands have been fabricated on wheels to allow the bed from being relocated from one place to another. The wheels are also provided with the braking system to cause the bed to remain stationary when required.

Figure 4.5.8 Stands and adjustment leg, thigh and back rests frame.
Source: Photograph by the Researcher, 2018

Figure 4.5.9 shows the nature of the 6mm thick ply wood that is cut using the power saw. The ply is covered by the synthetic rubbers of 6mm thick on either side to give the safety rail the required softness to accommodate knocks.

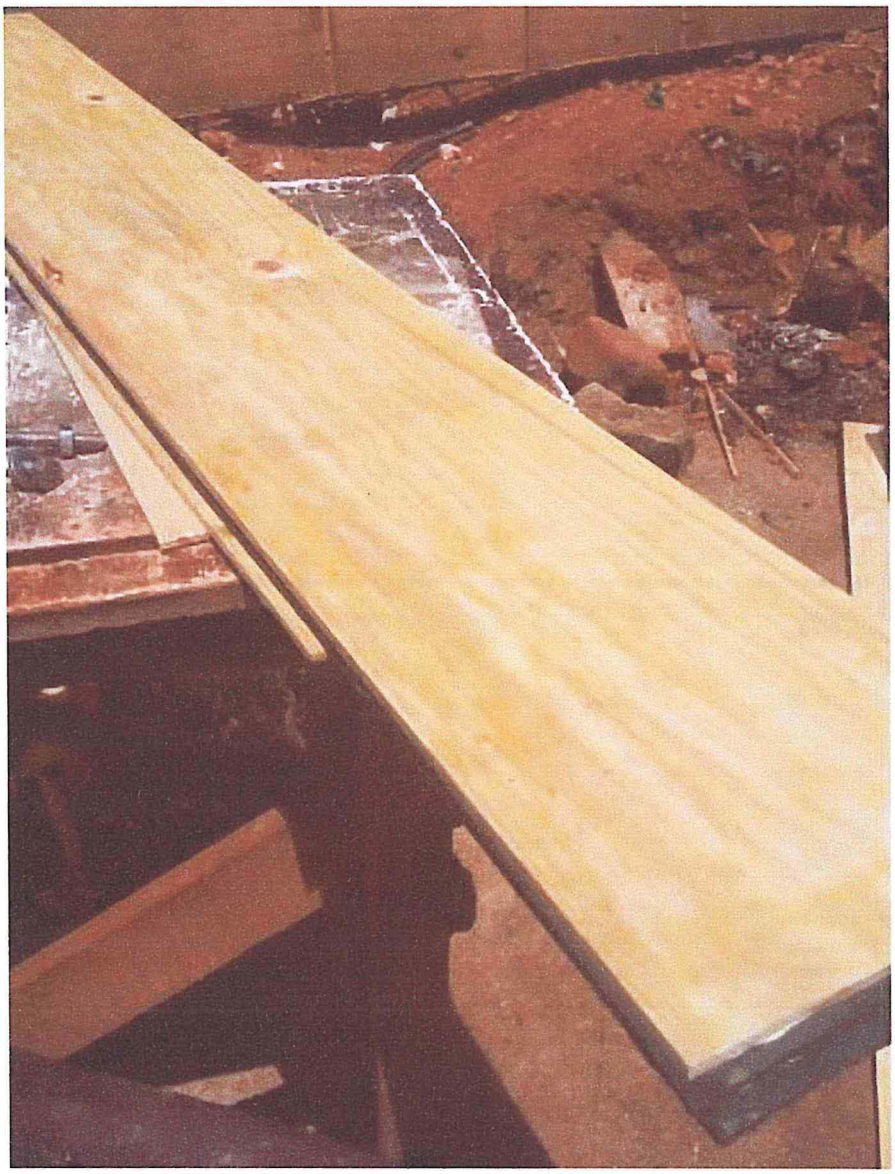


Figure 4.5.9: 6mm thick safety rail ply being ripped with a power saw.
Source: Photograph by the Researcher, 2018

Figure 4.5.10 shows the 6mm thick synthetic rubber being cut to size and glued to the ply on either side. Turf adhesive is used to bond the ply and the synthetic rubbers.

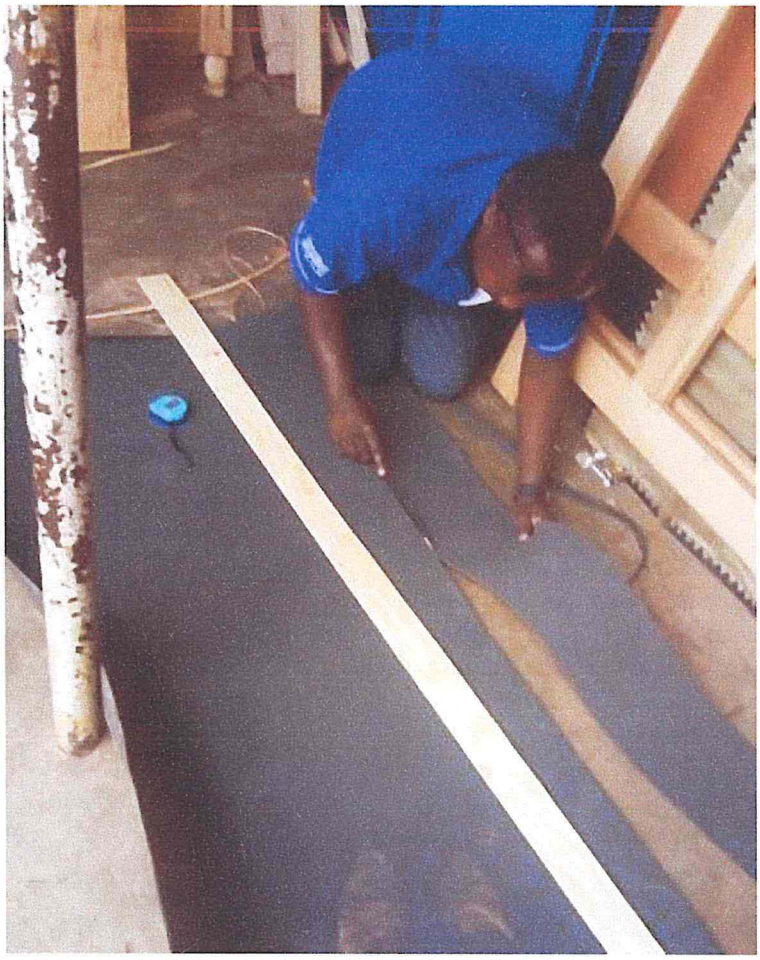


Figure 4.5.10: 3mm thick synthetic rubber being cut to size and glued to the ply.
Source: Photograph by the Researcher, 2018

Figure 4.5.11 shows the procedure followed to bond the 6mm thick synthetic rubber to the ply on either side. The turf adhesive is applied to both the ply surface and on the synthetic rubber surface.

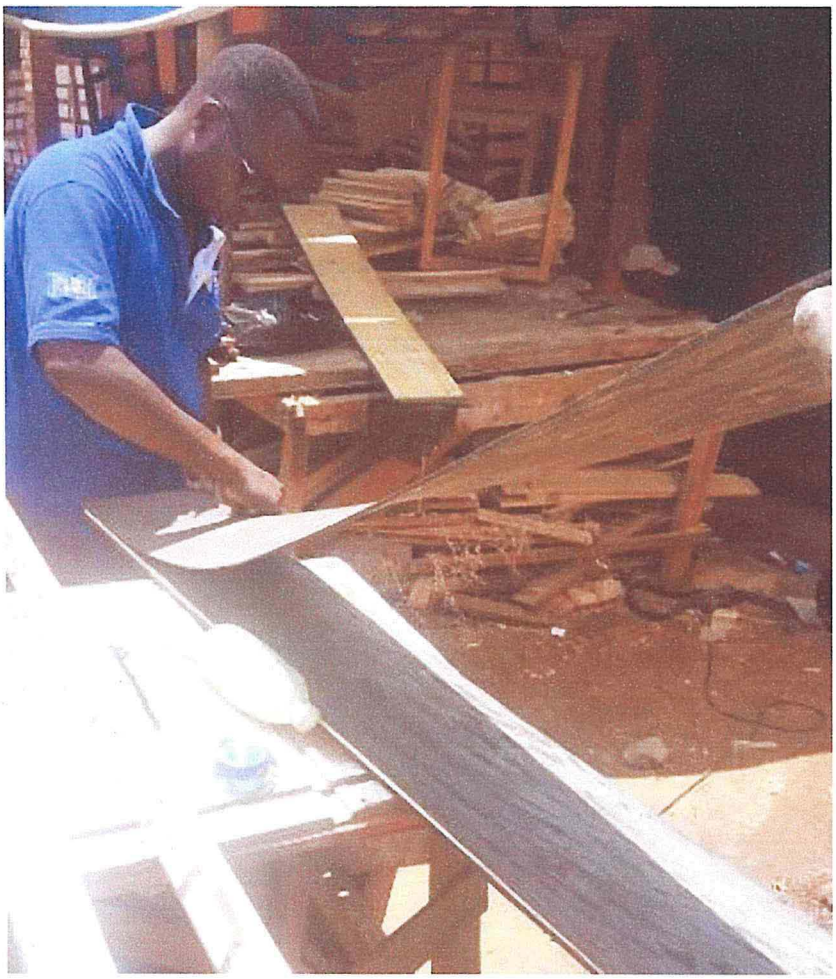


Figure 4.5.11: Synthetic rubber being cut to size and glued to the ply.
Source: Photograph by the Researcher, 2018

Figure 4.5.12 shows how the safety pads attached to the front and hind stands are being fixed using the 6mm bolts and nuts. The front and hind stands were fabricated with the provisions of receiving the safety pads.

Figure 4.5.12 Safety rail being fixed on the safety bed rail framing.
Source: Photograph by the Researcher, 2018

Figure 4.5.13 shows the cutting process of the synthetic leather used for covering the safety rails. The synthetic leather covers the synthetic rubber inside and gives a fine finish on the safety rails. The leather is liquid proof and easily cleaned when required.

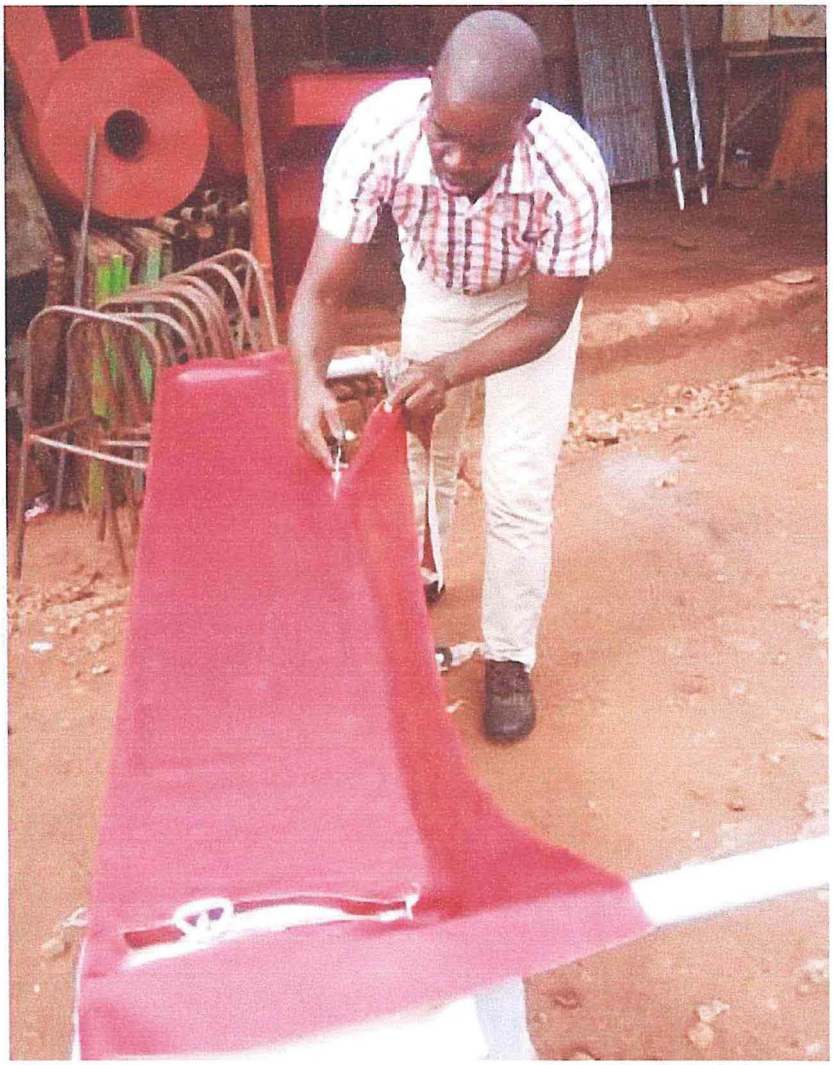


Figure 4.5.13 Synthetic leather being cut ready to cover the safety rails.
Source: Photograph by the Researcher, 2018

Figure 4.5.14 shows the application of the turf adhesive on the surface of the already fixed safety rails, readying it to be covered with synthetic leather. The adhesive is also applied on the Synthetic leather and allowed to set before being bonded together.

Figure 4.5.14: Turf adhesive being applied on Synthetic rubber, safety rail frame and synthetic leather prior bonding them together
Source: Photograph by the Researcher, 2018

The synthetic leather is water proof, easily cleaned when dirty, comfortable and gives good finish outlook to the low cost ward bed. Turf adhesive (glue) is used for bonding the leather on the synthetic rubber of the safety guard rails. Should the bed occupant become unconscious and starts knocking him/her self on the bed surfaces, the safety rails shall protect such a bed occupant from getting injured. This is because of the soft nature of the finishing provided to the rails. Should the leather develop any form of holes due to unwarranted pricks or scratches, the replacement is made easily. The scratched leather surface is removed, the new one cut to size and fixed to the surface using turf glue locally called gum.

Figure 4.5.15 shows the researcher finishing the safety rails, hind and front upper stand sections with leather. The finishing of the ends required much time and patience.

Figure 4.5.15 Finishing safety rails, hind and front upper stand sections with leather
Source: Photograph by the Researcher, 2018

4.6.1: Usability of the prototype low cost general ward bed

The low cost bed is designed and fabricated with improved functions and it is provided with the mosquito net hanging provisions among others. It is developed from an African Elephant (Loxodonta) as an inspiration object. The bed is finished and branded to meet the national, regional and international standards. It will be suitably used in general, private or labour wards. The standard Loxodonta bed will measure 1980mm x 910mm x 500mm high from the floor.

4.6.1.1 Using the low cost general ward bed for providing medical care to patients

This low cost general ward bed has been designed with the height lifting and lowering mechanical mechanisms. When the medical staffs require providing care on the patient at a certain height, the bed is easily adjusted to that height using the central screw jack provided underneath it. Should there arise conditions that require the patient to be protected from falling off the bed, the medical staff or patient attendants shall release the bolts and nuts provided to the side rails and make the necessary adjustment to protect the patient from any falling off dangers. Should the patient request care givers to help him/her to raise his/her back or thighs or the legs, then head and backrests or the thigh and back rests provided to the bed shall be adjusted using the mechanical screws attached to the front and rear ends of the bed. These have been designed to increase on the comfort of bed occupants. In the event that the medical staff of the patient attendants wish to move the patient bed to another location, the wheels designed with the braking system shall then be released so as to allow motion when only required and when not required, the brakes are engaged. The brakes are provided diagonally, one at the front stand and another at the rear stand.

Figure 4.6.1 shows the assembled Loxodonta bed when used for providing medical care to patients. If the need to put the bed occupant on water or blood transmission, the water or blood sachet is clipped on the front or hind stand bend whichever is applicable. Also in cases where privacy of the patient is required in the open ward, the front and hind stands can be used to hang the temporary curtains.

Figure 4.6.1: Loxodonta bed when used for providing medical care to patients
Source: Photograph by the Researcher, 2018

Figure 4.6.2 shows a medical doctor giving the health care to the patient during the trail of the Loxodonta bed prototype. Patients and medical staff appreciated the innovation and design and wished if the Loxodonta bed could be donated to Banda health community centre

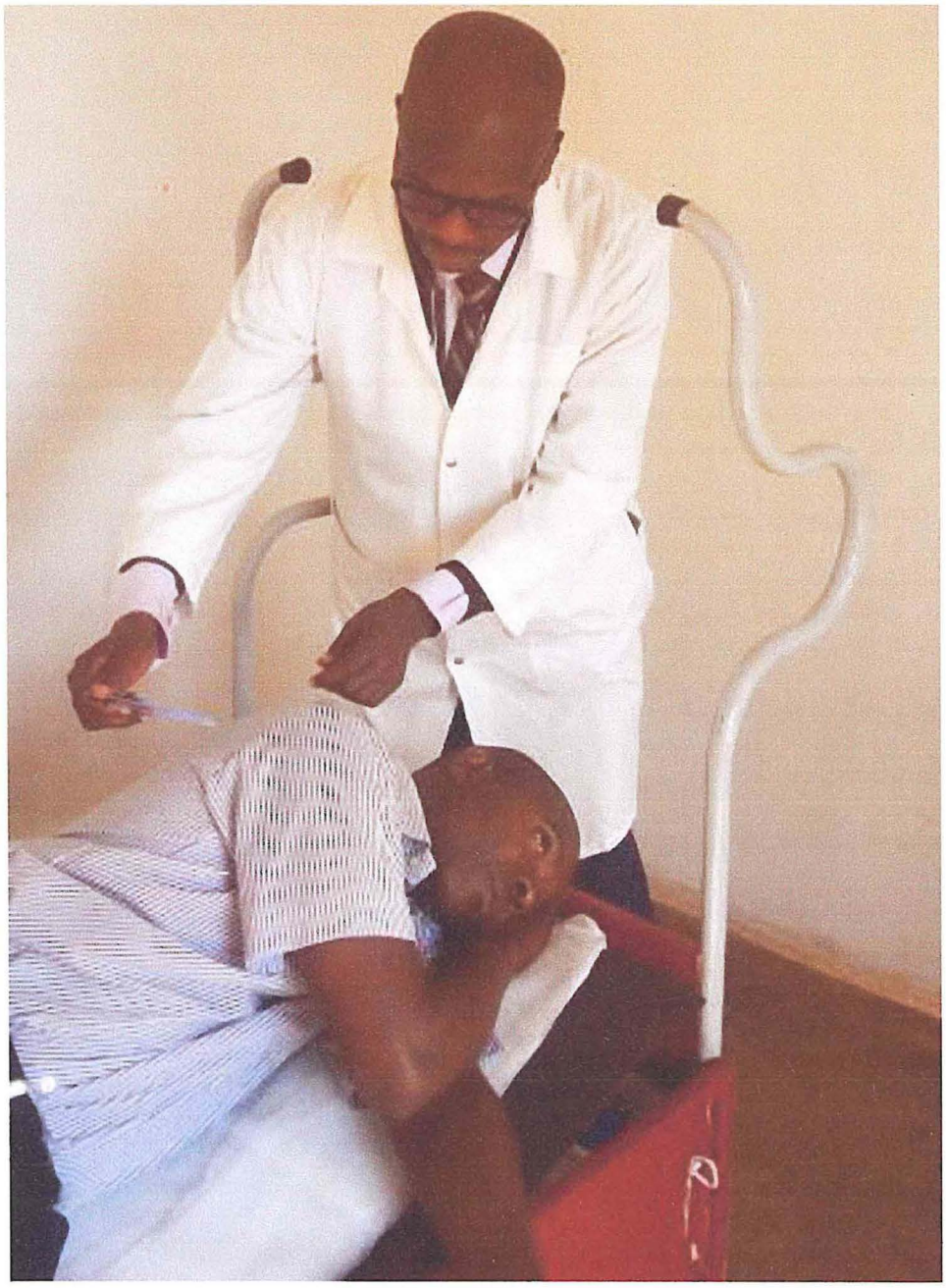


Figure 4.6.2: Loxodonta bed prototype on trail and being used for providing medical care to patient
Source: Photograph by the Researcher, 2018

When the medical staff and patients who used the bed at Banda Community Health centre were about the suitability of the Loxodonta ward bed, the patients said it is a good bed because it allowed the legs or back to be raised, it had protecting guard rails that id protect them from any possibility of falling off the bed and the mosquito nets were easily hanged on the bed without difficulty. The patients added that they felt good and relieved while on such a comfortable ward bed and that extending the bed to another location in the ward was performed with ease as the wheel were rolling to any given direction. The medical staff on the other hand appreciated the innovation, saying that the bed allowed them to raise and lower the patient to a convenient work table height. They also stated that that the bed provision for hanging drip water/blood and mosquito net was exciting and appreciated

4.6.1.2 Using the low cost general ward bed as worktable/ labour bed

When the bed is to be used on labour ward for delivering babies, the back stands curved arms are provided with any piece of cloth can be put on to increase on the comfort of the mothers legs being lifted up for some time. Depending on the stature of the mother being helped, the bed frame shall be detached from both the front and rear bed stands by the help of the bolts and nuts easily fastened using human hand force. On detaching the frame from the stands which are performed when the mother is on the bed, the frame of the bed shall then be adjusted to the required work table height using the mechanical crew jack fixed at the centre of the bed and under the plat form frame. The side safety rails may be used to protect the mother against any falling off the bed. The mechanical screw jack provided to lift the bed occupants up is designed to carry working loads up to 3000 kilograms. This guarantees the safety of the patients or mothers using the bed. Figure 4.6.3 shows the Loxodonta bed adjusted and ready to be used as work table/ Labour bed

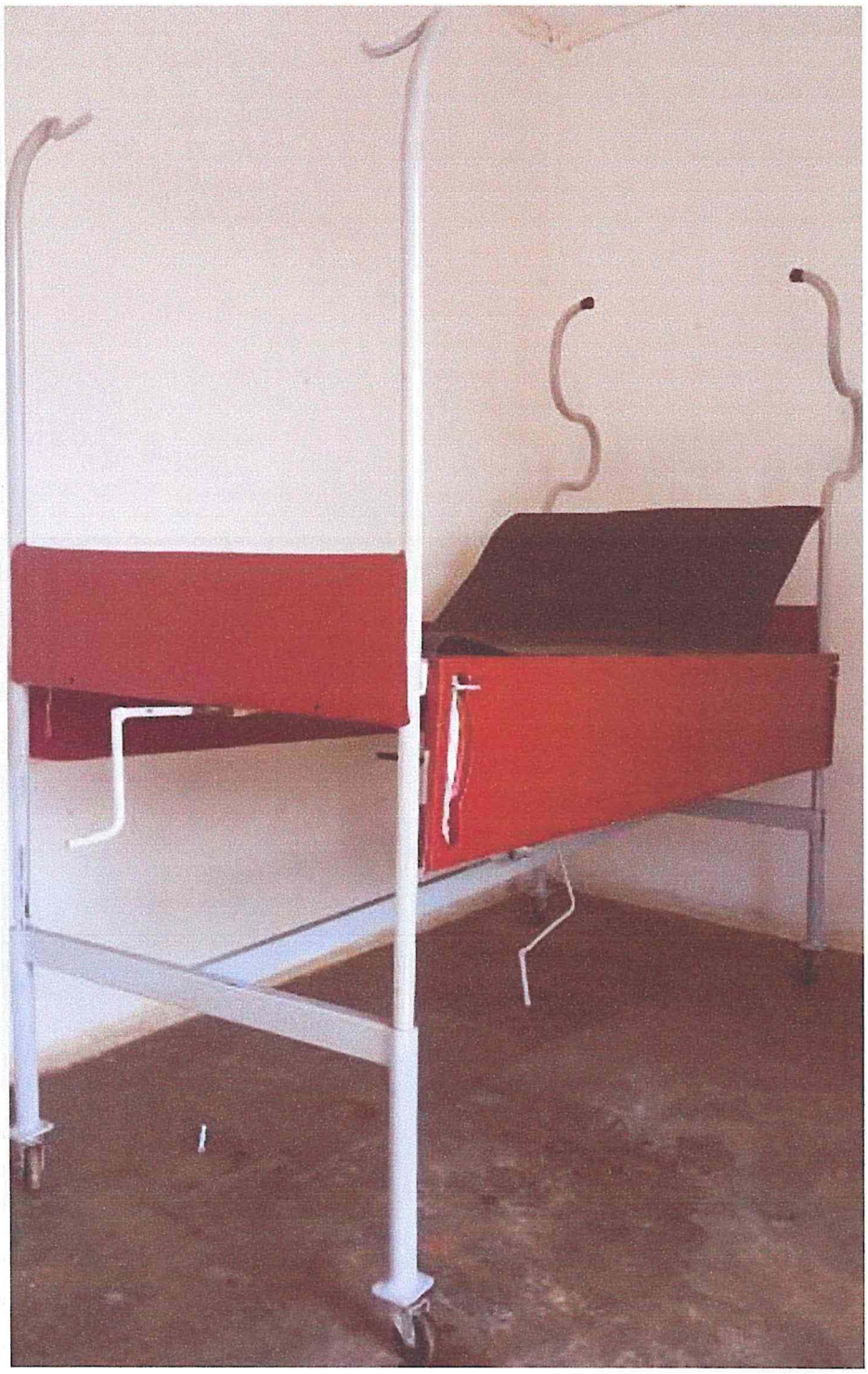


Figure 4.6.3: Loxodonta bed as work table/ Labour bed
Source: Photograph by the Researcher, 2018

4.6.1.3 Using the low cost general ward bed for hanging mosquito nets

When the need arises to protect the bed occupant from mosquito bites, the 3 feet by 6 feet mosquito net shall be hanged easily on the front and rear stands of the bed. The stands do not require any other fastening the mosquito net onto the stands. Ensure that the internal corners of the net are corresponding to the four bed stands as shown in figure 4.6.4. The mosquito net shall require to be tacked underneath the perimeter of the mattress.

Figure 4.6.4: Loxodonta bed used for hanging mosquito net
Source: Photograph by the Researcher, 2018

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECCOMENDATIONS

5.0 Overview

This chapter presents the summary, conclusions to the study and recommendations there after

5.1 Summary

The study on designing adaptable low cost ward bed for health facilities in Uganda is real and timely. The purpose of this study was to design adaptable low cost ward bed with improved functions using the locally available materials that are affordable. The objectives included find out the types of bed designs available in Atutur Hospital, analysing the effects of low bed-patient ratio in health facilities, developing the design of the prototype of the adaptable low cost ward bed as inspired by the Loxodonta.

The research project used a case study as a study design. The study design provided the researcher with the visual outlook of the bed designs found in the hospital. It enabled the researcher to collect a systematic factual and accurate description of existing situations facing patients in general wards. It also gave the researcher a complete picture of the general ward set up, its conditions, the materials used for making existing beds, costs used for procuring the existing beds and where the beds were from. This supported the researcher in making cost effective analysis of the prototype as compared to the existing beds. The study employed both random and purposive sampling that enabled proper representation of the target population hence increasing the reliability of the data collected. The data was collected using interviews, observations, photography, and studio experimentation. The data was analysed following the responses given against each guiding question, observation and the backing photograph and conclusions made.

The researcher intends to disseminate the findings of the project report by publishing it online using what's up and face book applications, publishing the findings using the New vision print media on Education guide platform provided every Wednesday for articles that are viewed to be creating an impact in the society. The researcher is also going to take the prototype locally adaptable low cost patient ward bed for public exhibitions

5.2 Findings

The study found out that there are few ward beds in Atutur hospital as compared to the number of patients lying on ward floors. The patients in paediatric ward are made to share beds in most cases. This situation made many patients to get infected with complicated diseases and. Patients lying on the ward floors have got bacterial infections and this has kept them in the hospital for long. Patients do not have mosquito net hanging provisions in while in the wards and this accelerated the rate of malaria infections among them. Many have lost their lives and resources due to the low bed patient ratio in the facilities. The Loxodonta ward bed occupies the same space like the existing plain beds except that the Loxodonta bed has improved functions.

The few available beds in the health facilities do not provide their occupants with ideal care needs. Although there are few beds with improved functions in the health facilities, these beds are expensive and not affordable for Atutur hospital. The study found out that the low cost loxodonta bed design is appropriate for Atutur hospital. This is because the improved functions on the expensive beds have been integrated on its design. Furthermore, the loxodonta bed is used for hanging mosquito nets which are not on the expensive beds. The low cost bed design provides for use as an emergency labour bed.

The study found out that it was possible to produce the low cost loxodonta ward bed prototype because the materials are locally available and sourced. The loxodonta ward bed prototype is affordable for Atutur hospital and other health facilities to procure. Although the study found out that the cost of the loxodonta ward bed is half the cost of the imported bed, the loxodonta bed has a mosquito hanging provision which is not on the imported bed.

The cost of maintaining and repairing the loxodonta bed shall be lower than that of the imported bed.

5.2 Conclusions

The beds are few in health facilities. Patients are contracting diseases because they sleep on the ward floors. Patients are dying because of overcrowding and sharing of the available beds has promoted the spread of communicable killer diseases. A section of the patients have stayed home due to the bad conditions they have always met in the wards. Loxodonta local adaptable low cost ward bed is cheaper and long lasting and can be locally procured. There are no local manufacturers of hospital beds with improved functions in Uganda like those provided for in the Loxodonta design.

5.3 Recommendations

1. Since the beds are a necessity and the patients' right, the government should procure the Loxodonta low cost ward bed for patients
2. The fact that beds with improved functions are expensive and imported, locally made adaptable Loxodonta ward bed should be promoted
3. With the governments' campaign of "Buy Uganda Build Uganda", government and other development partners should sponsor the procurement of the local adaptable low cost Loxodonta ward beds for health facilities
4. Institutions of Higher Learning and other academicians can take on further research from where this study has stopped

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APPENDICES

Appendix 1: A map of Uganda showing the location of Atutur Hospital – Kumi District where the Research is to be conducted

Appendix 2: World Hospital bed density

The table 1: World countries and their ranking on hospital beds densities per 10,000 population

SN	Country	Bed Density per 10,000 people	Year
1	Monaco	138 beds/10,000 population	2012
2	Japan	137 beds/10,000 population	2009
3	Korea, North	132 beds/10,000 population	2012
4	Belarus	113 beds/10,000 population	2011
5	Korea, South	103 beds/10,000 population	2009
6	Russia	97 beds/10,000 population	2006
7	Ukraine	90 beds/10,000 population	2012
8	Germany	82 beds/10,000 population	2011
9	Austria	76 beds/10,000 population	2011
10	Kazakhstan	72 beds/10,000 population	2012
10	Hungary	72 beds/10,000 population	2011
11	Lithuania	70 beds/10,000 population	2011
12	Czechia	68 beds/10,000 population	2011
12	Mongolia	68 beds/10,000 population	2012
13	Belgium	65 beds/10,000 population	2012
13	Poland	65 beds/10,000 population	2011
14	Bulgaria	64 beds/10,000 population	2011
14	France	64 beds/10,000 population	2011
15	Gabon	63 beds/10,000 population	2010
15	Ethiopia	63 beds/10,000 population	2011
16	Moldova	62 beds/10,000 population	2012
16	Barbados	62 beds/10,000 population	2012
17	Romania	61 beds/10,000 population	2011
18	Slovakia	60 beds/10,000 population	2011
19	Timor-Leste	59 beds/10,000 population	2010
19	Latvia	59 beds/10,000 population	2011
19	Croatia	59 beds/10,000 population	2014
20	Greenland	58 beds/10,000 population	2009
21	Tajikistan	55 beds/10,000 population	2011
21	Finland	55 beds/10,000 population	2011
22	European Union	54 beds/10,000 population	2011
22	Serbia	54 beds/10,000 population	2009

22	Luxembourg	54 beds/10,000 population	2010
23	Estonia	53 beds/10,000 population	2011
23	Cuba	53 beds/10,000 population	2012
24	Saint Vincent and the Grenadines	52 beds/10,000 population	2012
25	Nepal	50 beds/10,000 population	2006
25	Nauru	50 beds/10,000 population	2010
25	Switzerland	50 beds/10,000 population	2011
26	Palau	48 beds/10,000 population	2010
26	Malta	48 beds/10,000 population	2012
26	Greece	48 beds/10,000 population	2009
26	Kyrgyzstan	48 beds/10,000 population	2012
27	Azerbaijan	47 beds/10,000 population	2012
27	Netherlands	47 beds/10,000 population	2009
27	Argentina	47 beds/10,000 population	2012
27	Faroe Islands	47 beds/10,000 population	2012
28	Slovenia	46 beds/10,000 population	2013
29	Macedonia	45 beds/10,000 population	2011
30	Uzbekistan	44 beds/10,000 population	2010
31	Maldives	43 beds/10,000 population	2009
32	Turkmenistan	40 beds/10,000 population	2012
32	Montenegro	40 beds/10,000 population	2011
33	Australia	39 beds/10,000 population	2010
33	Armenia	39 beds/10,000 population	2012
34	Dominica	38 beds/10,000 population	2012
34	San Marino	38 beds/10,000 population	2012
34	China	38 beds/10,000 population	2011
35	Libya	37 beds/10,000 population	2012
36	Sri Lanka	36 beds/10,000 population	2012
36	Seychelles	36 beds/10,000 population	2011
37	Grenada	35 beds/10,000 population	2012
37	Lebanon	35 beds/10,000 population	2012
37	Denmark	35 beds/10,000 population	2010
37	Cyprus	35 beds/10,000 population	2011
37	Bosnia and Herzegovina	35 beds/10,000 population	2010
38	Mauritius	34 beds/10,000 population	2011
38	Italy	34 beds/10,000 population	2011
38	Portugal	34 beds/10,000 population	2011
39	Norway	33 beds/10,000 population	2011

39	Israel	33 beds/10,000 population	2012
40	Micronesia, Federated States	32 beds/10,000 population	2009
40	Iceland	32 beds/10,000 population	2012
41	Spain	31 beds/10,000 population	2011
41	Suriname	31 beds/10,000 population	2010
42	Sao Tome and Principe	29 beds/10,000 population	2011
42	Bahamas, The	29 beds/10,000 population	2011
42	United Kingdom	29 beds/10,000 population	2011
42	United States	29 beds/10,000 population	2011
42	Ireland	29 beds/10,000 population	2011
43	Brunei	28 beds/10,000 population	2012
44	Marshall Islands	27 beds/10,000 population	2010
44	Trinidad and Tobago	27 beds/10,000 population	2012
44	Sweden	27 beds/10,000 population	2011
44	Namibia	27 beds/10,000 population	2009
44	Canada	27 beds/10,000 population	2010
45	Tonga	26 beds/10,000 population	2010
45	Georgia	26 beds/10,000 population	2012
45	Albania	26 beds/10,000 population	2012
46	Turkey	25 beds/10,000 population	2011
46	Uruguay	25 beds/10,000 population	2012
46	Andorra	25 beds/10,000 population	2009
47	Saint Kitts and Nevis	23 beds/10,000 population	2012
47	New Zealand	23 beds/10,000 population	2011
47	Brazil	23 beds/10,000 population	2012
48	Comoros	22 beds/10,000 population	2006
48	Kuwait	22 beds/10,000 population	2012
48	Panama	22 beds/10,000 population	2011
49	Chile	21 beds/10,000 population	2011
49	Bahrain	21 beds/10,000 population	2012
49	Tunisia	21 beds/10,000 population	2012
49	Thailand	21 beds/10,000 population	2010
49	Antigua and Barbuda	21 beds/10,000 population	2011
49	Cape Verde	21 beds/10,000 population	2010
49	Swaziland	21 beds/10,000 population	2011
49	Equatorial Guinea	21 beds/10,000 population	2010
49	Saudi Arabia	21 beds/10,000 population	2012
50	Fiji	20 beds/10,000 population	2009

50	Guyana	20 beds/10,000 population	2009
50	Singapore	20 beds/10,000 population	2011
50	Zambia	20 beds/10,000 population	2010
50	Vietnam	20 beds/10,000 population	2010
50	Zambia	20 beds/10,000 population	2010
50	Vietnam	20 beds/10,000 population	2010
51	Burundi	19 beds/10,000 population	2011
51	Malaysia	19 beds/10,000 population	2012
52	Vanuatu	18 beds/10,000 population	2008
52	Botswana	18 beds/10,000 population	2010
52	Bhutan	18 beds/10,000 population	2012
52	Jordan	18 beds/10,000 population	2012
53	Jamaica	17 beds/10,000 population	2012
53	Zimbabwe	17 beds/10,000 population	2011
53	Oman	17 beds/10,000 population	2012
53	Dominican Republic	17 beds/10,000 population	2011
54	Saint Lucia	16 beds/10,000 population	2011
54	Rwanda	16 beds/10,000 population	2007
54	Ecuador	16 beds/10,000 population	2011
55	Colombia	15 beds/10,000 population	2012
55	Syria	15 beds/10,000 population	2012
55	Peru	15 beds/10,000 population	2012
55	Laos	15 beds/10,000 population	2012
55	Mexico	15 beds/10,000 population	2011
56	Kenya	14 beds/10,000 population	2010
56	Djibouti	14 beds/10,000 population	2012
57	Paraguay	13 beds/10,000 population	2011
57	Kiribati	13 beds/10,000 population	2011
57	Kiribati	13 beds/10,000 population	2011
57	Malawi	13 beds/10,000 population	2011
57	Haiti	13 beds/10,000 population	2007
57	Iraq	13 beds/10,000 population	2012
57	Solomon Islands	13 beds/10,000 population	2012
57	Cameroon	13 beds/10,000 population	2010
57	Gaza Strip	13 beds/10,000 population	2010
57	Lesotho	13 beds/10,000 population	2006
58	Costa Rica	12 beds/10,000 population	2012
58	West Bank	12 beds/10,000 population	2010

58	Qatar	12 beds/10,000 population	2012
59	Belize	11 beds/10,000 population	2012
59	El Salvador	11 beds/10,000 population	2012
59	United Arab Emirates	11 beds/10,000 population	2012
59	Gambia, The	11 beds/10,000 population	2011
59	Bolivia	11 beds/10,000 population	2012
60	Central African Republic	10 beds/10,000 population	2011
60	Philippines	10 beds/10,000 population	2011
60	Guinea-Bissau	10 beds/10,000 population	2009
61	Ghana	09 beds/10,000 population	2011
61	Morocco	09 beds/10,000 population	2012
61	Nicaragua	09 beds/10,000 population	2012
61	Venezuela	09 beds/10,000 population	2011
61	Indonesia	09 beds/10,000 population	2012
62	Liberia	08 beds/10,000 population	2010
62	Congo, Democratic Republic Of The	08 beds/10,000 population	2006
62	Sudan	08 beds/10,000 population	2012
63	Yemen	07 beds/10,000 population	2012
63	India	07 beds/10,000 population	2011
63	Togo	07 beds/10,000 population	2011
63	Honduras	07 beds/10,000 population	2012
63	Mozambique	07 beds/10,000 population	2011
63	Eritrea	07 beds/10,000 population	2011
63	Tanzania	07 beds/10,000 population	2010
63	Cambodia	07 beds/10,000 population	2011
64	Guatemala	06 beds/10,000 population	2011
64	Pakistan	06 beds/10,000 population	2012
64	Bangladesh	06 beds/10,000 population	2011
64	Burma	06 beds/10,000 population	2006
65	Benin	05 beds/10,000 population	2010
65	Egypt	05 beds/10,000 population	2012
65	Afghanistan	05 beds/10,000 population	2012
65	Uganda	05 beds/10,000 population	2010
66	Burkina Faso	04 beds/10,000 population	2010
66	Mauritania	04 beds/10,000 population	2006
66	Sierra Leone	04 beds/10,000 population	2006
66	Cote d'Ivoire	04 beds/10,000 population	2006
67	Guinea	03 beds/10,000 population	2011

67	Senegal	03 beds/10,000 population	2008
68	Madagascar	02 beds/10,000 population	2010
69	Mali	01 beds/10,000 population	2010
69	Iran	01 beds/10,000 population	2012

Source: CIA World Fact book (2017) Hospital bed density

Appendix 3: Data collection tools for the Research project

Questionnaire for Hospital Administrators

Introduction:

Dear respondent, my name is **Benard Akol Otemor**, a student of Kyambogo University offering the Master of Art and Industrial Design (Specialising in Interior Design). Am conducting the research on the beds for in-patients in general wards at Atutur Hospital for purposes of increasing access of the beds to all its inpatients. I welcome your support and I promise to keep all the information you provide confidential and will only be used for this academic purposes. This questionnaire is to be filled by you or your representative.

Section A: Demographic data.

1. Name of the respondent .....
2. Age ..... Sex .....
3. Place of work .....
4. Position held/Title .....

Section B: General ward hospital beds for in-patients.

1. Can you list down the types of hospital beds that you have in Atutur hospital?

   .....

2. Can you mention any difference in bed designs used in different wards?

   .....

3. Are there cases when the patients become many than the beds available in the wards?

   .....

4. What does the hospital do to the patients in wards without beds?

   .....

5. How do you ensure that the patients in wards without beds and sleeping on floors are protected from infections. .....
6. How appropriate are your beds in facilitating the patients change of position?

.....

7. How do you ensure that the patient is protected from falling off the bed?

.....

8. How do you ensure hygiene of the beds used in the wards? .....

.....

9. How do you fix mosquito nets on the beds?

.....

10. What type of materials are used for making the existing hospital beds?

.....

END

Interview Guide for staff in the ward-To is administered by the Researcher.
Introduction:

Dear respondent, my name is **Benard Akol Otemor**, a student of **Kyambogo University** offering the Master of Art and Industrial Design (Specialising in Interior Design). Am conducting the research on the beds for in-patients in general wards at Atutur Hospital for purposes of increasing access of the beds to all its inpatients. I welcome your support and I promise to keep all the information you provide confidential and will only be used for this academic purposes.

Name of the respondent .....

Age ..... Sex .....

Place of work ..... Resident of .....

Position held/Title .....

1. Do you have enough beds in the wards?
   .....
2. Are there cases when the patients in the ward become many than the available beds?
   .....
3. What does the hospital do when the patients in the ward become many than the available beds? .....
4. How do you ensure that the patients in wards without beds and sleeping on floors are protected from infections. .....
5. Where does the hospital get the beds from? .....
6. For how long do the admitted patients stay in the wards
   .....

END

Interview Guide for patients and attendants in the ward-- To be administered by the Researcher.

Introduction:

Dear respondent, my name is **Benard Akol Otemor**, a student of **Kyambogo University** offering the Master of Art and Industrial Design (Specialising in Interior Design). Am conducting the research on the beds for in-patients in general wards at Atutur Hospital for purposes of increasing access of the beds to all its inpatients. I welcome your support and I promise to keep all the information you provide confidential and will only be used for this academic purposes.

Name of the respondent .....

Age ..... Sex .....

Resident of..... Occupation .....

Place of work .....

1. When were you admitted into the ward?

   .....

2. How did you get this space or bed?

   .....

3. How do you fix a mosquito net on the bed

   .....

   .....

4. Are there cases of some patients staying in wards without beds?

   .....

5. How do the patients in wards without beds and sleeping on floors protect themselves from infections. .....

6. How do you maintain hygiene in the ward?

   .....

END

Observation check list-- To be administered by the Researcher.

1. The different types of beds for in-patients at Atutur Hospital
2. The bed occupancy compared to the patient's numbers in the wards
3. Materials used for making the beds
4. The different bed designs at the hospital
5. How the patients who are not able to move are helped
6. How patients' are protected from disease infections within the ward
7. How mosquito nets are fixed on beds
8. How patients are protected against falling off the bed
9. Ward exterior and interior designs
10. Spacing of beds in the wards
11. Lavatories and other waste disposal
12. Any observation the researcher comes across and the values as useful to the research.

END

Photography guide-- To be administered by the Researcher.

1. The different types of beds for in-patients at Atutur Hospital
2. The bed occupancy compared to the patient's numbers in the wards
3. Materials used for making the beds
4. The different bed designs at the hospital
5. Fixing of mosquito nets
6. protection of patients against falling off the bed
7. Ward exterior and interior designs
8. Spacing of beds in the wards
9. Lavatories and other waste disposal
10. Any scene the researcher comes across and the values as useful to the research.

END