ELECTRONIC HEALTH ORGAN DONATION AND FUNDRAISE TRACKING SYSTEM

BY

GROUP 2

DEPARTMENT OF INFORMATION SYSTEMS

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

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DECLARATION

As Group 2, we hereby declare that the information presented in this project report is our original work and that to the best of our knowledge, neither the study nor the same report has been presented to another university for the award of Bachelor of Information Systems and Technology of Makerere University.

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DEDICATION

This piece of work is dedicated to people who have made us what we are today and tirelessly worked hard to ensure that we attain this level of education. Special thanks go to our lovely parents and other family members, our supervisor Dr. Annabella Habinka, our Head of Department Dr. Agnes Nakakawa, other lecturers and well-wishers who have taught, supported and guided us since year one. Their academic, spiritual, and moral contributions shall eternally be in our memories. May God reward them all abundantly.

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LIST OF ABBREVIATIONS

AATB	American Association of Tissue Banks
Admin	Administrator
API	Application Programming Interface
AOPO	Association of Organ Procurement Organization
CHS	College of Health Sciences
CKD	Chronic Kidney Disease
CLD	Chronic Liver Disease
CoCIS	College of Computing and Information Sciences
CSS	Cascading Style Sheets
DCD	Donation After Cardiac death
DFD	Data Flow Diagram
EBAA	Eye Bank Association of America
E-Health	Electronic Health
ERD	Entity Relationship Diagram
ESKD	End Stage Kidney Disease
EU	European Union
FK	Foreign Key
GB	Gigabyte
GDP	Gross Domestic Product
GUI	Graphical User Interface
HTML	Hypertext Markup Language
IIAM	International Institute for the Advancement of Medicine
ICT	Information and Communication Technology
ID	Identification
ISP	Internet Service Provider
IST	Information Systems and Technology
IT	Information Technology
LRC	Low Resource Countries
MHZ	Megahertz
MySQL	My Structured Query Language

NATCO	North American Transplant Coordinator's Organization
OPO	Organ Procurement Organization
OPTN	Organ Procurement and Transplantation Network
OTP	One-time password
PIN	Personal Identification Number
PHP	Hypertext Preprocessor
PK	Primary Key
RAM	Random Access Memory
RDMS	Relational Database Management System
SCIT	School of Informatics and Technology
SDLC	System Development Life Cycle
SMS	Short Message Service
SMSS	Self-Management Support System
SQL	Structured Query Language
SSA	Sub Saharan Africa
Txt	Text
UNOS	United Network for Organ Sharing
WHO	World Health Organization
XAMPP	X (Cross-platform), Apache, MySQL, PHP, and Perl

ABSTRACT

Today's Electronic Health Organ Donation and Fundraise Tracking systems pose different requirements and challenges in terms of registration, donor-recipient matching, organ removal, organ delivery, and transplantation with legal, clinical, ethical, and technical constraints. There is a huge gap between donors and recipients of organs in Uganda making it difficult for the patients to access the required and needed organs on time. Hence it is against this background that we proposed and developed an Electronic Organ Donation and Fundraise Tracking System to provide convenience in accessing organs by patients from the available donors. The study's findings will enable the tracking of the availability of organs and potential donors and fundraisers in Uganda. Through linking the patients, fundraisers and donors directly thus being able to exchange contact information with each other.

The project was designed using Data Flow Diagrams (DFDs) for the process model and Entity Relationship Diagrams (ERDs) for the data model. It was implemented using technologies such as; Hypertext Markup Language (HTML) for the interfaces, Cascading Style Sheet (CSS) for styling the interfaces, bootstrap for responsiveness, Hypertext Preprocessor (PHP) for connecting the database and the interfaces, and My Structured Query Language (MySQL) for the database. The system has different users with different roles that is; the administrator, the donor and the patient each having their own login sessions and permissions.

The developed system was tested and validated with its results indicating that it is sufficient to be a solution for the problem indicated below. The study's findings enabled the tracking of the availability of organs, potential donors and fundraisers in Uganda. Through linking the patients, fundraisers and donors directly thus being able to exchange contact information with each other.

In conclusion, the core reason for the establishment of an Electronic Health Organ Donation and Fundraise Tracking system was to reduce the inefficiency in organ availability, delivery and tracking in Uganda. Therefore, the technologies used supported the core objective of the system of bridging the tracking gap among the various stakeholders.

Key words: E-Health, Fundraising, Organ Donation, Tracking, Transplant, System

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CHAPTER ONE: INTRODUCTION

1.1 Introduction Overview

This study is aimed at developing an electronic health organ donation and fundraise tracking system that tracks availability of organs and potential donors in Uganda. This section presents the background of the study, the problem statement, objectives of the study, scope and significance of the study.

1.2 Background

Digital transformation of health care is an evolving trend with technologies such as the Internet of things, virtual care, remote monitoring, artificial intelligence, big data analytics, block chain, smart wearables, platforms, tools enabling data exchange and storage and tools enabling remote data capture the exchange of data and sharing of relevant information across the health ecosystem (WHO, 2019). This therefore creates a continuum of care that has proven potential to enhance health outcomes by improving medical diagnosis, data-based treatment decisions, digital therapeutics, clinical trials, self-management of care and person-centered care as well as creating more evidence-based knowledge, skills and competence for professionals to support health care (WHO, 2019).

E-health is an emerging field in public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies (Duettmann et al., 2021). In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology (Duettmann et al., 2021).

The necessity for organ donation has increased worldwide in the past years due to an increase in organ failure (Lewis et al., 2021). With the growing number of illnesses and health difficulties due to internal organ failure, the preferred treatment for most organ failure is transplantation (Citerio et al., 2016). Transplantation program is a complex healthcare service which involves vast costs and requires highly skilled health experts, complex infrastructure and equipment, and well-articulated legal frameworks to enable its operationalization (O'Connell et al., 2020).

The lack of organ donors has become a limiting factor for the development of organ transplantation programs. Many countries are currently facing a severe shortage of organs for transplantation (Dibaba et al., 2020). Organ transplantation is a unique procedure that cannot take place without either the donation or buying of an organ from another person. Every day in the United States of America (USA), 17 people die waiting for an organ and more than 100,000 men, women, and children await life-saving organ transplants (Health Resources & Services Administration, 2022). According to a survey in India every year about 500,000 people die because of non-availability of organs and 150,000 people await a kidney transplant but only 5000 get among them (Kalmath et al., 2021).

Organ transplantation offers a unique chance to extend and/or save lives and improve the health of those in need (Villines, 2019). The number of organ transplants has grown steadily over the past 65 years, with more than 750,000 transplants conducted in the United States since 1988 (Division of Transplantation, 2019). However, the need vastly outweighs the number of available organs. According to the Division of Transplantation (2019) report of The National Survey of Organ Donation Attitudes and Practices, approximately 20 people on the national organ transplant waiting list die each day, while every 10 minutes a new person is added to that list.

Some of organs that can be transplanted are Kidneys, Heart, Liver, Lungs, and Pancreas etc. with the kidney being the most commonly transplanted organ. According to the United Network for Organ Sharing (UNOS), between January 1, 1988, and June 30, 2016, an estimated 669,556 organs were transplanted in the United States (Saleh, 2021). Although these numbers are remarkably impressive, there simply aren't enough organs available for those who need them (Saleh, 2021). Currently, 120,139 people are in need of life-saving organ transplantation (Saleh, 2021).

Sub-Saharan Africa (SSA), occupying about 80% of the African continent is a heterogeneous region with estimated population of 1.1 billion people in 47 countries (Ulasi et al., 2020). Most belong to the low resource countries (LRCs). The high prevalence of end-organ diseases of kidney, liver, lung and heart makes provision of organ donation and transplantation necessary (Ulasi et al., 2020). Although kidney and heart transplantations were performed in South Africa in the 1960s, transplant activity in SSA lags behind the developed world (Ulasi et al., 2020). Peculiar challenges

militating against successful development of transplant programs include high cost of treatment, low Gross domestic product (GDP) of most countries, inadequate infrastructural and institutional support, absence of subsidy, poor knowledge of the disease condition, poor accessibility to health-care facilities, religious and trade-cultural practices (Ulasi et al., 2020).

The need for appropriate interventions for organ failures in sub-Saharan Africa (SSA) is underscored by the high prevalence of end-organ diseases such as chronic kidney disease (CKD), chronic liver disease (CLD), chronic lung and heart diseases (interstitial lung disease, cystic fibrosis, cardiomyopathies and chronic rheumatic heart diseases) which cause increased morbidity and mortality (Ulasi, et al., 2020). For example, Kaze et al., (2018) in a systematic review of prevalence studies on CKD in SSA documented the highest prevalence in West Africa 19.8%, Central Africa 16%, East Africa 14.4%, and Southern Africa 10.4% (Kaze et al., 2018).

From the 2020 survey conducted by The World Health Organization (WHO) to determine the status of human organ and tissue donation and transplantation in the WHO African region, seven Member States in the African Region reported having functional transplantation programs in place, meaning that they have capability to perform kidney transplants and post-transplant management of recipients within the country's borders (WHO, 2020).

There are a total of 35 kidney transplant centers taking donations from living donors in the African Region (WHO, 2020). Namibia and Uganda reported one heart transplant center each, Algeria has 12 cornea transplant centers while Kenya has five (WHO, 2020). Algeria reported having three transplant centers for liver and five for bone marrow (WHO, 2020). Four Member States performed approximately 350 kidney transplants from living donors according to the survey conducted (WHO, 2020). Due to limited national capacity for kidney transplant programs, some countries have put in place hemodialysis centers while starting such programs (WHO, 2020).

Recently published report has found that approximately 3 million people in sub-Saharan Africa diagnosed with end-stage kidney disease (ESKD) die each year due to renal failure (Ashuntantang et al., 2017). In Kenya, the kidney transplant queue at Kenyatta National Hospital in Nairobi stretches all the way to 2018, despite the hospital performing the procedure on a weekly basis

(Dibaba et al., 2020). In Ethiopia, between 130 and 150 corneas are collected yearly, however, there are more than 300,000 blind people waiting for corneal transplantation (Gesesse et al., 2021).

1.2.1 Organ Donation and Transplant in Uganda

In 2021, the Ugandan cabinet approved the Human Organ Donation and Tissue Transplant Bill 2020 (Kiiza, 2021). It was meant to regulate the removal, storage transformation of human organs, tissues and cells for therapeutic purposes and to establish the Ugandan Organ Transplant Council (Okoth, 2021). It would also provide for the designation of hospitals and transplant centers, the approval of human organ, tissue and cells donations and transportations (Okoth, 2021).

Uganda is in the process of initiating tissue and organ transplant to serve the ever growing need to reduce mortality and morbidity (Integrated Biorepository of H3Africa, 2021). Government has invested in this field through sponsoring overseas training for experts who will be tasked with performing these procedures. The team set out to widen the scope and introduce tissue and organ bio banking at Makerere University, to provide a service, advance training and research in this field. The team set out to widen the scope and introduce tissue and organ bio banking at Makerere University, to provide a service, advance training and research in this field (Integrated Biorepository of H3Africa, 2021).

According to Dr. Nakwagala, patients who sought an organ transplant of any nature abroad spent between \$25,000 (sh90m) to \$30,000 (sh108m) for the procedure (Okoth, 2021). This excluded indirect costs of transports and accommodation which she said could amount to \$10,000 (sh36m) and she also added that the costs would be brought down once the procedure is done in Uganda (Okoth, 2021).

Bunori et al., (2022) conducted a study at four health facilities that provide kidney dialysis in Kampala, Uganda. Structured questionnaires were used to interview caregivers for patients with end-stage renal disease (ESRD) (Bunori et al., 2022). 125 participants were enrolled with a mean age of 32.3±9.8 years and found 68 (54.4%) participants were willing to donate a kidney for transplant (Bunori et al., 2022). Willingness to donate a kidney was more likely among older caregivers namely those aged 25–34 years (aPRR, 1.15; 95% CI, 1.01–1.31) and ≥35 years (aPRR

1.16; 95% CI, 1.05–1.29) compared to those aged 18–24 years, females compared to males (aPRR, 1.30; 95% CI, 1.19–1.42), those with a positive attitude towards organ donation (aPRR, 1.24; 95% CI, 1.13–1.36), and when organ kidney donation was permissible by the participant's religious faith (aPRR, 1.11; 95% CI, 1.01–1.22) (Bunori et al., 2022). Contrariwise, willingness to donate a kidney was less likely when the family did not approve of kidney donation (aPRR, 0.80; 95% CI, 0.71–0.90) (Bunori et al., 2022). There is no platform in Uganda that can help in organ donation and fundraise tracking.

1.3 Statement of the problem

One of the biggest problems in organ donation is the gap between the patients in need of organs and those willing to give the organs. They lack a platform that can connect patients to potential donors, fundraisers and track availability of organs.(Magembe, 2021). Where patients are waiting for a kidney, heart, pancreas, and liver, or lung, demand outstrips supply and patients sometimes die while still to receive an organ.

Another cause is that lack of money/funds to pay for transplant services since such surgeries are highly expensive to carry out. There are also very few people who are willing to donate their organs to the people in need of healthy ones thus making the organ supply low.

Therefore, this study aims to develop an online system "An Electronic Health Organ Donation and Fundraise Tracking system" via which willing donors can be able to donate funds to cater for some patients transplant operations, register for organ donation to enable easy tracking for availability of organs and potential donors in Uganda,
so, as the donors can interact with the patients since there is no such system in Uganda at the moment basing on the background study and literature review.

1.4 Objectives of the study

1.4.1   Main Objective

To develop an Electronic Health Organ Donation and Fundraise Tracking system that enables fundraising for transplant operations, registration for organ donation and tracking availability of organs and potential donors and fundraisers in Uganda.

1.4.2 Specific Objectives

1. To identify the system requirements for an Electronic Health Organ Donation and Fundraise Tracking system.
2. To design an Electronic Health Organ Donation and Fundraise Tracking system.
3. To implement an Electronic Health Organ Donation and Fundraise Tracking system.
4. To test and validate an Electronic Health Organ Donation and Fundraise Tracking system.

1.5 Scope of the study

1.5.1 Content Scope

The scope includes identification and collection of requirements necessary for the development of the system and their analysis. Then a description of the recommended solution was converted into logical and then physical system specifications. The study concentrated on the implementation of an Electronic Health Electronic Health Organ Donation and Fundraise Tracking system that enables the tracking of the availability of organs and potential donors in Uganda. The system allows people, through internet, to create accounts, register for donation and confirm transactions. The system is then maintained and improved. The system includes a fundraising platform for people that might not be willing to donate organs but can make donations in form of currency to facilitate patient's bills and also keep the system running.

1.5.2 Geographical Scope

The study was conducted in and around Makerere University located in Kampala, Uganda since there is a conveniently available pool of respondents that is to say Makerere College of Computing and Information Sciences (CoCIS), School of Informatics Technology (SCIT) which will enable quick and easy acquisition of data and college of Health sciences (CHS) for the organs and patients' information.

1.5.3 Time scope

The study considers a time period of four months during which the following activities will be achieved: proposal development, data collection and analysis, design, implementation, and testing and validation of the Electronic Health Organ Donation and Fundraise Tracking System.

1.6 Significance of the study

1. The study's findings enabled the tracking of the availability of organs and potential donors and fundraisers in Uganda. Through linking the patients, fundraisers and donors directly thus being able to exchange contact information with each other.
2. Improve donors and patient relationships.
3. In future, the researchers, lecturers, and students can use the findings of the study for referential purposes in further research.

1.6.1 Developers

The research helped the programmers or developers with all the required information that will be needed to develop the Electronic Health Organ Donation and Fundraise Tracking system.

1.6.2 Donors and Patients

The system eases communication among/ connections between donors, fundraisers and patients since they would be able to exchange contact information via the system. It will create users with security and boost the confidence. The system will also provide a platform for transitioning and donating organs legally.

1.6.3 Management team and support stuff.

The system helps the team and support stuff with real-time track of donors, fundraisers and patients on the waiting list, organs available for transplant. It also provides proper instructions on how to use the system.

1.6.4 Future researchers

The study intents to provide accurate information about Electronic Health Electronic Health Organ Donation and Fundraise Tracking system to help the future researchers have proper knowledge for their research.

CHAPTER TWO: LITERATURE REVIEW

2.1. Overview

This section focuses on the existing literature that is related to Electronic Health Organ Donation and Fundraise Tracking systems. It explains the critical analysis of the research works from books, internet sources and individual studies that exist in relation system.

2.2. Electronic Health

Electronic Health (E-Health) is a new field in medicine that includes the use of electronic devices, modern electronic technologies, and any electronic applications to support the health of patients comprising electronic processes for data exchange and communication of healthcare professionals (Duettmann et al., 2021).

2.3. Organ Donation

Organ donation is the giving of an organ and tissue to help someone that needs a transplant (Health Department, 2021). Transplants can save or transform the life of a person. One organ and tissue donor can help transform the lives of more than 10 people. This relies on donors and their families agreeing to donate their organ and tissue after death (Health Department, 2021). In developed countries such as USA, registration to become a donor is quite easy and convenient since there are a variety of online systems via which registration can take place. For example, the Organ Donor website (www.OrganDonor.gov) which is the official U.S. Government Web site for organ donation and transplantation.

2.3.1. E-Health and Organ Donation

E-Health has the potential to change all phases of transplantation: improve processes before transplantation, during the transplant processes itself, and after transplantation (Duettmann et al.,

eHealth in transplantation, 2021). In the pre-transplant phase, unique electronic techniques can help to promote organ donation, for example, by sharing knowledge, personal experiences, and scientific literature (Duettmann et al., 2021). E-Health-based educational lessons about life-donor procedures are a useful tool for donor education, modern clinical decision support systems assist in living kidney donor assessment and such e-Health solutions may even increase the number of living donor transplantations (Duettmann et al., 2021). Better software tools may improve waitlist management, data exchange, and communication with patients and doctors before transplantation (Duettmann et al., 2021).

2.3.2. Fundraising

Fundraising is raising money for an organization or a project. It's finding different ways to collect the required amount of money. With fundraising you can collect money from governments, private investors, philanthropists, or simply people who care and want to help.

2.3.2.1. Crowd funding

Crowd funding refers practice of funding a project or venture by raising money from a large number of people who each contribute a relatively small amount, typically via the internet.

2.3.2.2. Some of the fundraising systems

1. Chuffed:

   Chuffed is a crowd funding platform for socially-conscious projects. They support individuals, not-for-profits, social enterprises and community groups to run fundraising campaigns. www.chuffed.org
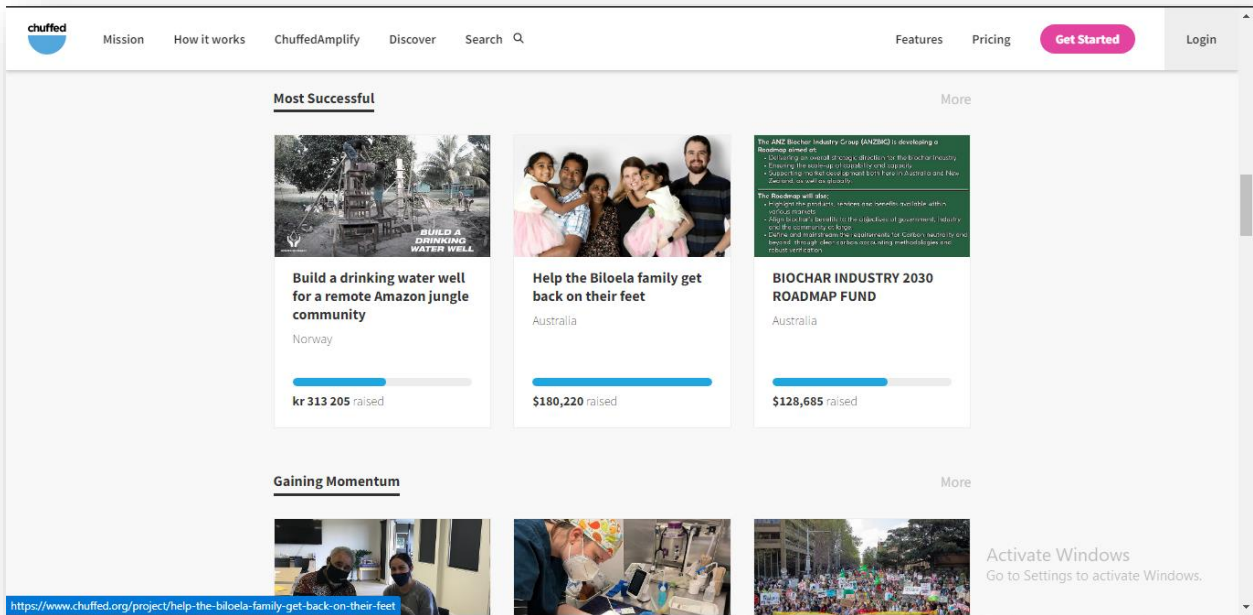
Figure 2.1 Chuffed Website 1

2. Go Get Funding:

GoGetFunding is a crowd funding website that lets you raise money for anything that matters to you. From personal causes and events to projects and more. www.gogetfunding.com
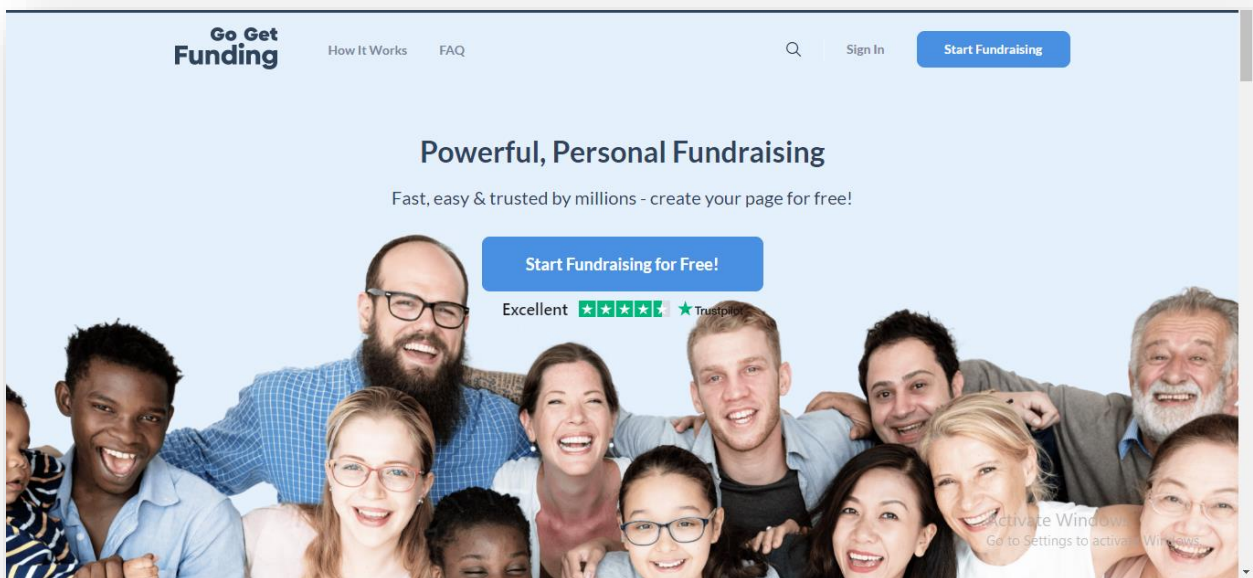
Figure 2.2: GoGetFunding Website

2.3.3. Why is donation important?

There are many people on the organ transplant waiting list. Unfortunately, there are less donor organs available compared to the available number of patients in need. Some people die waiting for a transplant. Some spend weeks or months in hospital, while others make several trips to hospital every week for treatment. People in need of an organ transplant are usually very sick or dying, because one or more of their organs is failing. They range from children through to older people.

Many on the organ transplant waiting list have a congenital or genetic condition, illness or sudden organ failure that will make them very sick and in need of a transplant (Health Department, 2021). We never know when illness could affect a family member, friend or colleague who may need a transplant.

2.3.4. Organ donation in developed economies

In the European Union (EU), there are two types of institutional settings for organ donation: informed consent (opt-in) or presumed consent (opt-out) (Costa-Font et al., 2021). Under the 'opt-in' system (also called 'explicit consent' or 'informed consent' system), an individual or his/her family must give explicit permission for organ removal (Scholz, 2020). This is in countries such as the UK, Germany, and Sweden (Costa-Font et al., 2021).

The 'opt-out' system endorses the principle of 'presumed consent' (silence being tantamount to consent) unless a specific request for non-removal of organs for donation is made before death (Scholz, 2020). This is in countries such as Spain, Portugal, and Austria (Costa-Font et al., 2021). There are also mixed systems (Scholz, 2020). Some countries have developed donor and/or non-donor registries where citizens can record their wishes in this regard (Scholz, 2020).

2.3.5. Organ donation in developing economies

Economic deprivation in developing countries and the meager expenditure on health care translates into poor transplantation activity (Gjorgjievski et al., 2018). Although economic constraint is the

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main reason for poor transplantation activity in the region, it is not the only reason (Gjorgjievski et al., 2018). For example, the wealthy countries of the Middle East suffer from a lack of education and societal motivation for organ donation. Developing countries suffer jointly from economic difficulties and cultural and societal apathy toward organ donation (Gjorgjievski et al., 2018). Although brain death laws have been implemented in many countries, organ donation remains minimal. A classic example of socio-cultural resistance toward transplantation is to be found in mainly African countries such as Uganda where most people believe that a person is supposed to be buried with his organs (Magembe, 2021).

2.3.6. Pathways to organ donation

There are three pathways to organ donation:

a. Brain death:

This is where a person no longer has blood going to or activity in their brain due to a severe brain injury (Health Department, 2021). They have permanently lost the potential for awareness and the capability to breathe. This may happen even when a ventilator is keeping the person's heart beating and oxygen is circulated through their blood.

Brain death is different from being in a coma. A person in a coma is unconscious because their brain is injured in some way (Health Department, 2021). In a coma, the brain continues to function and may heal overtime whereas with brain death, there is no likelihood of recovery as the brain has stopped functioning and cannot recover. For brain death, a series of tests are carried out by two independent and properly qualified senior doctors to establish that death has occurred (Health Department, 2021).

b. Circulatory death:

Circulatory death occurs when the heart has irreversibly stopped beating and when circulation and oxygenation to the tissues irreversibly stops (Suzanne, 2014). It can also be the planned withdrawal of life-sustaining treatment from a patient within the Intensive Care Unit or the Emergency Department (Health Department, 2021).

For this case, the patient is monitored closely and donation will only precede once circulation irrevocable ceases. The timeframes for this organ donation pathway are very short for the reason that organs cannot be without oxygenated blood and outside the body for a long period of time.

c. Living donation

This a donation that's done when the person is still alive and healthy. You can choose to donate a kidney, a small section of your liver, or discarded bone from a hip or knee replacement (Health Department, 2021).

2.4. Organ Procurement

Organ procurement (also called organ harvesting) is a surgical procedure that involves the removal or organs or tissues for reuse, typically for organ transplantation (NLM, 2005).

2.4.1. Procedure

If the organ donor is human, most countries require that the donor be legally dead for consideration of organ transplantation (e.g., cardiac or brain dead) (Lewis et al., 2021). But for some organs, a living donor can be the source of the organ such as donating one kidney or part of their liver to a well-matched recipient (Lewis et al., 2021). Organs cannot be procured after the heart has stopped beating for a long time thus, donation after brain death is generally preferred because the organs are still receiving blood from the donor's heart until minutes before being removed from the body and placed on ice (Lanese, 2019). In order to better standardize the evaluation of brain death, The American Academy of Neurology (AAN) published a new set of guidelines in 2010 and again affirmed in 2019. These guidelines require that three clinical criteria be met in order to establish brain death: coma with a known cause, absence of brain stem reflexes, and apnea (Biel & Durrant, 2020).

Donation after cardiac death (DCD) involves surgeons taking organs within minutes of the termination of respirators and other forms of life support for patients who still have at least some brain activity (Smith et al., 2012). This occurs in circumstances based on the patient's advanced directive or the family's wishes, the patient is going to be removed from life support (Smith et al., 2012). After this decision has been made, the family is contacted for consideration for organ

donation. There is a 2–5-minute waiting time to ensure that the potential donor's heart does not start beating again suddenly once life support has been withdrawn. Once the time elapses, the organ procurement surgery begins immediately to reduce time that the organs are not being perfused with blood (Smith et al., 2012). DCD had been the custom for organ donors until 'brain death' became a legal definition in the United States in 1981. Since then, most donors have been brain-dead (Truog et al., 2018).

If permission is provided by the potential donor or the potential donor's survivors, matching between the source (donor) and the target (recipient) is performed to reduce rejection of the organ by the recipient's immune system.

Often, co-ordination between teams working on different organs is necessary in case of multiple-organ procurement (Starzl et al., 1987). The quality of the organ then is certified. If the heart stopped beating for too long then the organ becomes unusable and cannot be used for transplant (Starzl et al., 1987).

2.5. Organ Transplantation

Organ transplantation is a medical procedure in which an organ is removed from one body and placed in the body of a recipient, to replace a damaged or missing organ (Deshmukh & Baheti, 2020). The organs may be transported from a donor location to another location or both the recipient and donor may be at the same location.

Organs that have been successfully transplanted include the heart, kidneys, liver, lungs, pancreas, intestine, thymus and uterus. Tissues include bones, tendons (both referred to as musculoskeletal grafts), cornea, skin, heart valves, nerves and veins (Cleveland Clinic, 2021). Internationally, the kidneys are the most commonly transplanted organs, followed by the liver and then the heart then the cornea and musculoskeletal grafts being the most transplanted tissues (Farhan et al., 2020).

2.5.1. Types of Transplants
1. Auto grafts:

These are the transplant of tissue to the same person. Sometimes this is done with surplus tissue, tissue that can regenerate, or tissues more desperately needed elsewhere examples include skin grafts, vein extraction for CABG, etc.

2. Allograft:

This is a transplant of an organ or tissue between two genetically non-identical members of the same species. Allografts can either be from a living or dead body.

3. Bone Graft:

This is a surgical procedure that uses transplanted bone to repair and rebuild diseased or damaged bones. A bone graft is a choice for repairing bones almost anywhere in your body. The surgeon might take bone from your hips, legs, or ribs to perform the graft (JHM, n.d., p. Bone Grafting).

4. Xenograft:

This term refers to a tissue or organ that is procured from a species that is different from the recipient of the specimen.

2.6. ICT in Organ Donation and Transplantation

1) Self-management support systems (SMSS) have been proposed for renal transplant patients to increase their autonomy and reduce the number of hospital visits (Wang et al., 2017). To investigate acceptance of a SMSS and the influencing factors, fifty renal transplant patients answered the questionnaire before and after using the SMSS for 4 months. All the questionnaire constructs had a satisfactory or higher level of reliability (Wang et al., 2017).

2) The use of ICT for the remote monitoring of transplant patients can help provide patients with space and freedom to live life as normally as possible, in their home environment (European Commission, 2011). Projects such as this are helping the EU to become a smart, sustainable and inclusive economy (European Commission, 2011). The aim of the Prometheus project is to develop the remote monitoring of transplant patients through the installation of computers in the home, in order to connect patients to a health care team, and help facilitate their social and professional reintegration from within their home environment, while at the same time reducing the economic burden of transplant care and improving the allocation of transplant grafts (European Commission, 2011).

3) In the donor organ transplant system, A.I. uses machine learning models that not only connect organ donors to recipients but also predict the probability of an organ matching for longevity (Morande & Marzullo, 2019). Machine Learning models support transplant patients to monitor and manage body vitals during the transplant process (Morande & Marzullo, 2019).

Using the Block chain technology in organ donation, the matching process increases chances of promptly finding an appropriate match, while being completely secure (Alandjani, 2019). Confidentiality and privacy can be achieved using the encryption tools and techniques. Also, the authenticity can be done using the approved digital certificates issued by authorized healthcare bodies (Alandjani, 2019). Block chain uses the immutability of records and traceability of conditions to keep track of patient conditions, facilitating the exchange of information from origin to destination (Alandjani, 2019).

The convergence of Artificial Intelligence and Block chain systems extends organ matching capability that extends help to multiple individuals receive a transplant via a single organ donor (Díez-Sanmartín & Sarasa Cabezuelo, 2020).

2.7 Existing Organ Donation and Transplant Systems:

2.7.1Related Systems

1) Organ Donor website:

This is the official U.S. Government Web site for organ donation and transplantation. It contains the sign-up process which can easily be followed by the people. This website also teaches people about Donation, how it works, who can donate and what can be donated www.OrganDonor.gov
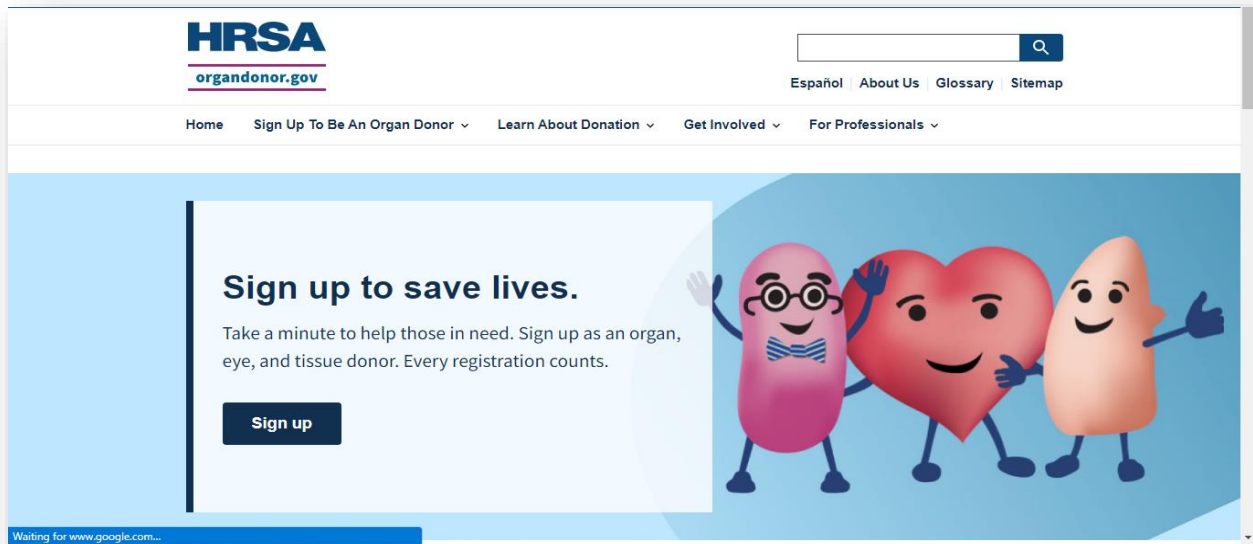
Figure 2.3: Organ Donor Website

2) IRODaT:

This is The International Registry of Organ Donation and Transplantation; it is a database that provides information by country of donation and transplantation activity. www.irodat.org
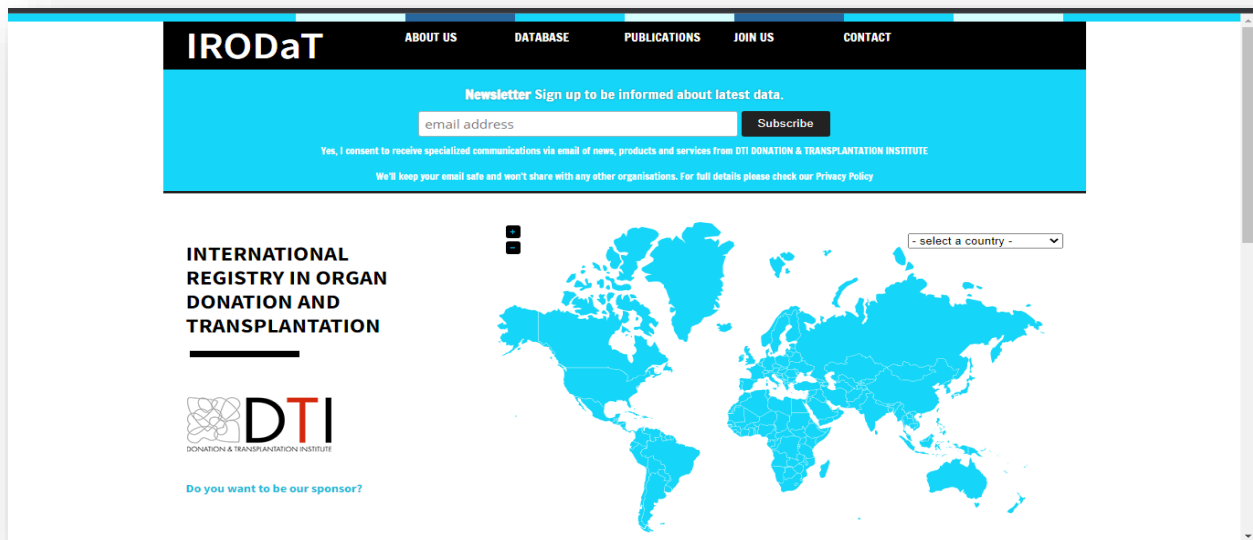
Figure 2.4: IRODaT Website

3) Donate Life:

It is an Australian website created by the Australian government that promotes organ donation awareness and also provide a platform where people can register to join the list of those who want to be donors. www.donatelife.gov.au
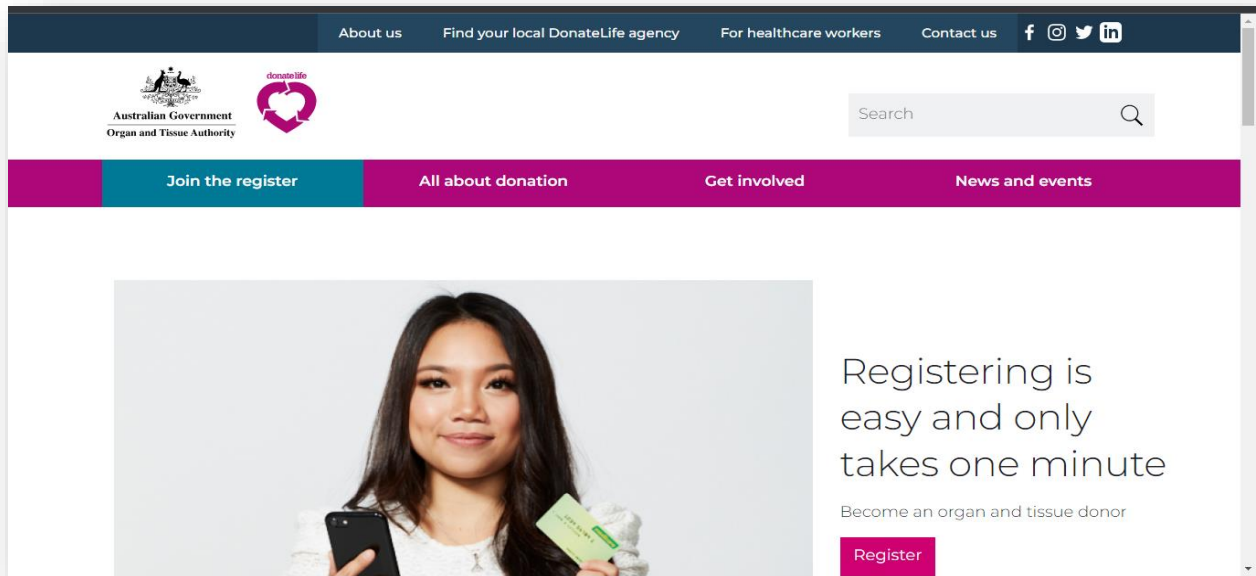
Figure 2.4: Donate Life Website

4) Organ Procurement and Transplantation Network:

This Web site provides data and educational information about organ donation. The Organ Procurement and Transplantation Network (OPTN) is a unique public-private partnership that links all professionals involved in the U.S. donation and transplantation system. Also crucial to the system are individuals who sign organ donor cards, people who comment on policy proposals and countless volunteers who support donation and transplantation, among many others (HRSA, 2022). https://optn.transplant.hrsa.gov/
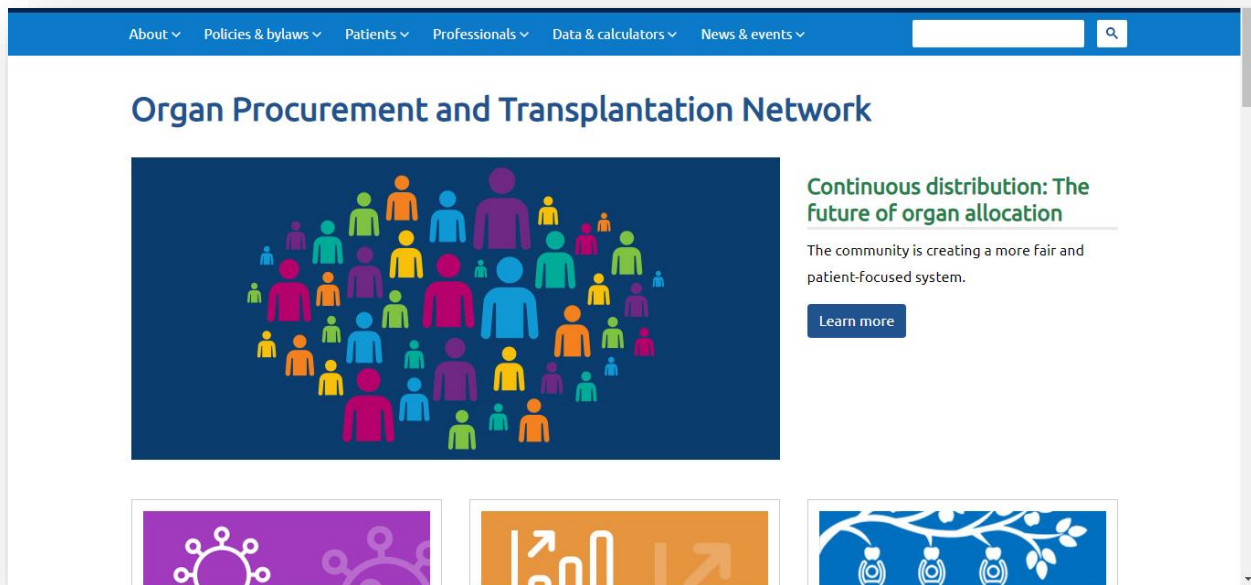
Figure 2.5: OPTN Website

2.8.1. Donation and Transplantation Organization Sites

2.8.1.1. Under Organ Procurement

1) Association of Organ Procurement Organizations (AOPO): National representative of organ procurement organizations (OPOs). www.aopo.org

2) The International Institute for the Advancement of Medicine (IIAM): Offers services for organ, tissue and whole-body donation for medical research and education when transplant options are not available. www.iiam.org

2.8.1.2. Under Tissue Donation

American Association of Tissue Banks (AATB): Facilitates the provision of high quality transplantable human tissue in quantities sufficient to meet national needs. www.aatb.org

2.8.1.3. Under Eye Donation

1) Eye Bank Association of America (EBAA): Dedicated to the restoration of sight through the promotion and advancement of eye banking. https://restoresight.org

2) Donor Awareness

3) Coalition on Donation: Dedicated to educating the public about organ and tissue donation, correcting misconceptions about donation and creating a greater willingness to donate. www.shareyourlife.org

4) The Nicholas Green Foundation: Set up by the green family, is a non-profit organization dedicated to furthering the cause of organ and tissue donation around the world. It does this by spreading information to increase awareness of the shortage of donors everywhere. It can also support a broad range of children's causes. www.nicholasgreen.org

2.8.1.4. Under Transplantation

1) Division of Transplantation: Provides Federal oversight and funding support for the nation's organ procurement, allocation, and transplantation system; coordinates national organ and tissue donation activities and funds research to learn more about what works to increase donation; administers the national bone marrow registry program. www.organdonor.gov

2) Trans Web: Information about transplantation and donation including pictures, stories, and audio clips of the US Transplant Games and Donor Recognition Ceremony. www.transweb.org

3) American Society of Transplantation: Transplant professionals dedicated to research, education, advocacy and patient care in transplantation science and medicine. www.a-s-t.org

4) North American Transplant Coordinator's Organization (NATCO): Professional society of more than 1,750 transplant coordinators representing the largest group of transplant professionals in North America www.natco.org.

5) The Gift of a Lifetime: In this dramatic photo-documentary journey, experience the stories of patients whose hopes rise and fall with each passing day as they wait for organ transplants. Learn how families look beyond their grief in order to give life to others www.organtransplants.org.

Table 2.1: Strengths and weaknesses of some existing Electronic Health Organ Donation and Fundraise Tracking systems

No	Application and link	Strengths	Weaknesses
1.	Organ Donor website: www.OrganDonor.gov	1. Clear guidelines and adequate information required for donors 2. Shows the current number of people in need of the organs	1. The statistical data they have is for the recent years (2021) yet we would like to track the trend of organ donation and transplantation for the previous years as well
2.	IRODaT: www.irodat.org	1. Illustrates clearly the donor statistics of particular organs in the previous year's graphically represented	1. Very little information about the donations and transplants 2. The statistical data they have is also for the recent years (2019) yet we would like to track the trend of organ donation and transplantation for the previous years as well
3.	Donate Life: www.donatelife.gov.au	1. Great display of the all the information they included about the donation including adequate explanation for full clarity 2. There is actual tracking of the donations and transplants made represented in numbers and this makes it easy for people to relate and if possible, donate accordingly	1. Mainly concentrate on organ donation yet donation of income from people can help a lot of individuals

2.9. Systems features Comparison

Table 2.2: Organ donation system's feature comparison table

Features of existing systems	Organ donor website	IRODaT	Donate Life	Organ procurement and transplantation network	Electronic health organ donation, fundraising and transplant tracking system
User account creation	Yes	Yes	Yes	Yes	Yes
Fundraise	No	No	Yes	No	Yes
Storing info on individuals	Yes	Yes	Yes	No	Yes
Patient donor activity tracking	No	No	No	No	Yes
Total sum of cash donations	No	No	No	No	Yes
Showing available organs	No	No	No	No	Yes
Direct consultation	No	No	No	No	Yes

2.10.   Summary

In summary, Technology has proven to be important in organ donation basing on the Information and Communication Technology (ICT) and e health sections. Electronic health has evolved over the years and with its evolvement, new trends like e-health organ donation and fund raising are still blossoming in developing countries but with adopting way forwards from already established countries with working and efficient e health organ donation systems, Uganda will be able to infiltrate it in the health sector.

As an e-health venture, with the help of related already existing systems like the one being used in the United States (organ donor.gov), a similar system is to be developed at the end of this project illuminating similar characteristics and functionalities Basing on the table 2.1, the system to be constructed (an Electronic Health Organ Donation and Fundraise Tracking system.) will have all the listed features and will be the first system of that kind to be setup in Uganda. The features include;

1) Connect Patients to donors.
2) Track available organs.
3) Fundraise.
4) Set Events.
5) Patients Make Organ requests.
6) Donors Donate organs.

CHAPTER THREE: METHODOLOGY

3.1. Introduction

This section will give a detailed description of tools, instruments, approaches, processes, data collection techniques and technologies that will be used to achieve the objectives of the study. These methodologies will be employed in the research study, data collection, analysis, design, implementation, testing and of the system.

3.2. Research design

A research design is a detailed outline of how an investigation will take place. The study will involve a cross-sectional research design because it will be carried out within a short period of 3 months and it is a case study where the researcher only handles one case. It involved a mixed-method research approach to realize the specific objectives. Thus, both library research where the researcher collects information from libraries, and field research where the researcher collects the information directly from the field will be used.

The rationale of using a mixed-method research approach is to get a detailed view of the research problem. Qualitative method for exploratory purposes will be used first then followed by the quantitative method to provide both generalized and detailed analysis of the research problem. Using the qualitative and quantitative methods, in-depth knowledge of different respondents will be obtained.

3.3. Target Population

The target population is the group of individuals that the intervention intends to conduct research in and draw conclusions from (Barnsbee & Nghiem, 2018). Thus, the target population of the study will be Makerere University College of Computing and Information Science students since they are close and easy to access.

3.4 Sampling Technique and Sample size

3.4.1 Sample Techniques

1) Convenience sampling:

This is a method adopted by researchers where they research data from a conveniently available pool of respondents. The sample size will be obtained from the Makerere University College of Computing and Information Science (CoCIS), School of Informatics Technology (SCIT) students since they are easily accessible thus enabling quick and easy acquisition of data.

2) Purposive sampling:

Purposive sampling, also known as judgmental, selective, or subjective sampling, is a form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their surveys.

3.4.2 Sample Size

The sample size for the specialists and students will be calculated using a mathematical formula of Yamane (Yamane, 1973) $n = \frac{N}{1+[N(e)^2]}$

Where, n = Sample size,

N = Population size,

e = Level of precision

The estimation of the students at CoCIS is 1300.

For 95% confidence level, p = 0.5 and ±5% precision. The resulting sample size is:

Sample size for students, $n = \frac{1300}{1+[1300(0.05)^2]}$

$$= \underline{305 \text{ students}}$$

Sample size for doctors, $n = \frac{5}{1+[5(0.05)^2]}$

$$= \underline{4 \text{ doctors}}$$

Table 3.1: Sample size Technique summary

Category	Population	Sample size	Selection Techniques
Doctors	05	04	Purposive Sampling
Students	1300	305	Convenience Sampling

| Total | 1305 | 309 | |

3.5. Research Methods

3.5.1. Qualitative research

Qualitative research is an iterative process in which improved understanding to the scientific community is achieved by making new significant distinctions resulting from getting closer to the phenomenon studied (Aspers & Corte, 2019). It focuses on the "why" rather than the "what" of social phenomena and relies on the direct experiences of human beings as meaning-making agents in their everyday lives (Beratlis, 2021).

Qualitative data will be obtained through the use of interviews, will be sorted, classified and categorized into various variables using Microsoft Excel.

3.5.2. Quantitative research

Quantitative research is the process of collecting and analyzing numerical data. It can be used to find patterns and averages, make predictions, test causal relationships, and generalize results to wider populations (Scribbr, 2020). This will be conducted using Questionnaires.

3.6. Data collection methods

Data is a collection of facts, figures, objects, symbols, and events gathered from different sources. Organizations collect data to make better decisions (QuestionPro, 2022). Without data, it would be difficult for organizations to make appropriate decisions, and so data is collected at various points in time from different audiences (QuestionPro, 2022).

In this project study, data collection methods will be used in gathering user requirements for the project and the research will rely on both primary and secondary data methods to collect first and second-hand information. Questionnaires and interviews will be used for primary data while literature reviews will be used for secondary data.

3.6.1. Interviews

Structured face to face interviews will be conducted and will target mainly people in the medical field (doctors). This method will be used because it is a certain way of getting correct and direct answers from the respondents and helps the researcher to get the in-depth data that may not be easily captured through the questionnaires. Interview questions are usually open-ended questions so that in-depth information will be collected (Virginia Tech, 2018). They help one explain, better understand, and explore research subjects' opinions, behavior, experiences, phenomenon, etc. (Virginia Tech, 2018). Check Appendix 2 for the interview guide.

3.6.2. Questionnaires

A questionnaire is used to collect data from respondents. Here the researcher will design semi-structured questions to capture information about the target population, the objectives of the study, the research questions and the hypothesis. The method will include mainly structured close ended questions designed in relation to the study objectives and study hypothesis. The researcher prefers to use this instrument so as to obtain data from respondents about their attitudes, experiences, or opinions because it will help the researcher to easily and scientifically analyze the data collected. Also, the use of questionnaires is likely to increase the degree of reliability due to the many items they can reach thus increasing data validity. Check Appendix 3 for the Questionnaire.

3.7.   Qualitative and Quantitative data analysis

Data analysis is defined as a process of cleaning, transforming, and modeling data to discover useful information for business decision-making (Creswell et al., 2018). Data analysis is an essential component of ensuring data integrity and appropriate analysis of research findings. The purpose of Data Analysis is to extract useful information from data and taking the decision based upon the data analysis (Creswell et al., 2018).

Qualitative data will be grouped according to different themes using Microsoft Word as the data analysis tool. Quantitative data analysis will be carried out using Microsoft Excel where graphs representing the data will be made.
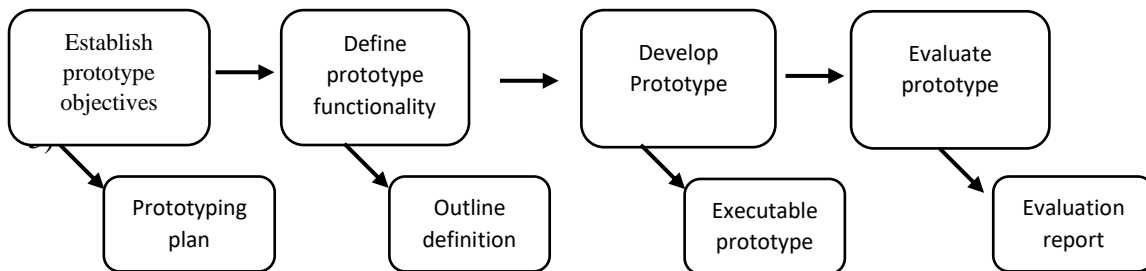
3.8.   System Design

System design will involve creating physical designs that will satisfy the requirements document. It will involve designing the user interface and identifying inputs, outputs and processes of the system. The output of the design will be the Electronic Health Organ Donation and Fundraise Tracking system.

1) Data Flow Diagram (DFD): A data flow diagram shows the way information flows through a process or system. It includes data inputs and outputs, data stores, and the various sub processes the data moves through.

2) Entity Relationship Diagram (ERD): An Entity Relationship Diagram illustrates how entities such as people, objects or concepts relate to each other within a system.

3.9.1   Software Development Model

The researchers will use Prototyping software development model to build the system. A prototype is a version of a system that is developed quickly to see if the customer is satisfied with it. The client's involvement in the development process increases the chances that the final product will be accepted early on. For this project, Makerere University students and patients at Makerere University Hospital will act as the users to test the system since they are easily accessible by the developers. The phases of a prototyping process are:

6) *Figure 3.1: Prototyping phases (source: https://onix-systems.com/blog/7-basic-software-development-models-which-one-to-choose)*

3.9.   System Implementation

3.9.1.   Coding

The implementation will be aided with either XAMPP or WAMP (Windows, Apache, MySQL, and PHP) software tools. These are packages with independently created programs installed on computers that use Microsoft Windows operating systems. Both have Apache, My Structured Query Language (MySQL) and one of PHP (Hyper-Text Pre-Processor). PHP is a scripting language that can manipulate information held in a database and generate web pages dynamically each time content is requested by a browser. PHP is used for the server programming in which queries are used to link the website to the database. Other programs will be included such as phpMyAdmin which provides a graphical user interface to the MySQL database manager.

All data manipulation and processing will be done using the following technologies;

1. Hyper Text Markup Language (HTML), which is easy to use and open source, will be used for interactive user interface design.

2. JavaScript (JS), which is also an easy-to-use open-source client-side scripting language, will be used to develop dynamic functionalities of the system. Its ability to display information in the browsers may also enable users to use the system.

3. Cascading Style Sheet (CSS) is also easy to use and will be used in formatting the user interfaces of the system.

4. PHP Hyper-Text Pre-Processor (PHP) that is also an easy-to-use open-source server-side scripting language will be used in connecting the user interfaces and the database.

5. My Structured Query Language (MySQL) that is easy to use, open source and scalable will be used for the database.

6. Bootstrap will be used for responsiveness of the system.

3.10.   System Security

The system will be intended to provide a login form for various stakeholders involved to prevent unauthorized users from accessing confidential information. Furthermore, data that will be input into the database of the system will be validated before submission so as to prevent wrong and inaccurate data from being captured and stored in the system's database.

3.11. System Testing

After the construction of the system, it will be tested by the developers using sample data on the basis of error rates to verify that it met design requirements. Testing will be done before and after the system has been put to use. This will involve different methods. We will only do three testing methods. Unit testing, integration testing and system testing.

1) Unit testing: This will be the first testing to be done in our system. Single units will be checked to ensure there are no errors.

2) Integration testing: This is a level of software testing where individual units are combined and tested as a group. The purpose of this level of testing is to expose faults in the interaction between integrated units.

3) System Testing: This is a black box testing technique performed to evaluate the complete systems compliance against specified requirements. In system testing, the functionalities of the system are tested from an end-to-end perspective.

4) Usability testing: Is a way to see how easy to use something by testing it with real users. Users are asked to complete tasks, typically while they are being observed by a researcher to see where they encounter problems and experience confusion.

3.12. Ethical Considerations

An introductory letter from the School of Computing and Informatics Technology, College of Computing and Information Sciences (CoCIS), Makerere University which will be presented to all respondents when requesting for information will be picked up. The researchers will have to seek for appointments from specialists (doctors) by presenting an introductory letter from the researchers' university of study, indicating that the study will be purely for academic purposes.

The researchers will observe ethical values during the study. For instance, they will introduce and identify themselves and honestly present to respondents the aims and objectives of the study. They will also ensure that respondents voluntarily agree to participate in the study. The researchers will ensure that items in the questionnaire and interview guide are constructed carefully so as to evoke the right responses and not to dig into the private lives of respondents outside the scope of the study. The data obtained from individuals will be kept confidential. No formal form of respondent identification will be disclosed other than references to respondents in form of unique

identification numbers. To ensure integrity, inappropriate relationships and related influences will be avoided.

3.13.   Summary

Table 3.2: Summary table

#	Specific Objectives	Tools and Techniques	Deliverables
1	To conduct a literature review and carry out a field study to identify the system requirements for an Electronic Health Organ Donation and Fundraise Tracking system.	1) Interviews 2) Questionnaires	System requirement specification documentation
2	To design an Electronic Health Electronic Health Organ Donation and Fundraise Tracking system	1) Data Flow diagrams (DFDs) 2) Entity relationship diagrams (ERDs) 3) Flow diagram	System design document
3	To implement an Electronic Health Electronic Health Organ Donation and Fundraise Tracking system	1) HTML 2) CSS 3) JavaScript 4) MySQL 5) PHP 6) Bootstrap	An Electronic Health Organ Donation and Fundraise Tracking system prototype
4	To test and validate an Electronic Health Electronic Health Organ Donation and Fundraise Tracking system	System testing document	Electronic Health Electronic Health Organ Donation and Fundraise Tracking system

This methodology has explained in detail the research design that the researchers shall undertake during development. It also entails the system development life cycle procedures that will be followed while developing the Electronic Health Organ Donation and Fundraise Tracking system, research methods, data collection methods, system implementation, security, testing and the ethical considerations undertaken while carrying out data collection.

CHAPTER 4: SYSTEM STUDY, ANALYSIS AND DESIGN

4.1. Introduction

In this chapter, a detailed description of an Electronic Health Electronic Health Organ Donation and Fundraise Tracking system is provided under which we cover functional and Non-functional requirements. It assesses the current state of organ donation in Uganda and gives an in-depth analysis of the requirements of the new Electronic Health Organ Donation and Fundraise Tracking system.

4.2. System study

A thorough investigation of the current process of organ donation was carried out in order to obtain detailed information about the new system that was to be designed. In this process, appropriate data collection instruments were used and these included; - interviews and questionnaires. The sample space for carrying out these interviews comprised of the students from the various faculties at Makerere University. This study was done to identify the problems and challenges faced by the existing system. The information collected at this phase from the prospective system users and key organizational stakeholders was critically analyzed, evaluated and findings reviewed to establish specific system objectives and user requirements. The findings of the study are presented as follows; -

4.2.1. Current system

Currently, an Organ Donation and Transplant Tracking system as such does not exist in Uganda, however a manual format of the organ donation process is undertaken in hospitals.

The living donor process: The living donor needs to undergo some medical tests and evaluations to check and confirm her/his medical compatibility with the recipient. The living donor's medical compatibility is confirmed by a doctor after all tests have positively confirmed that the donor is compatible with the recipient then the transplant takes place. The living donor's organs are retrieved surgically by doctors and stored in special chemical solutions briefly until the transplanted into the recipient.

The deceased donation process: A deceased donor is usually one who has suffered a fatal injury to the head or had Brain Hemorrhage. The donor's family has to give consent for the donation to take place while the doctors keep the donor on life support until the organs are retrieved. Suitable recipients are identified from a waiting list and notified to reach their respective hospitals.

However, in Mulago, the normal flow of events starts with a patient undergoing several tests and evaluations by the doctors. "Thorough viability assessments on organ recipients which other technologies such as scans may not enable them to do if they are to minimize rejection and infections after the procedures" said Dr. Zeridah Muyinda. Then the patient is added to list of those in need of an organ.

A team of doctors reviews each case to determine whether a referral is required, and this is where for many patients in need of advanced medical care, a referral is made though on many occasions the expense of going abroad is far beyond what they can afford on their own.

4.2.2. Strength of the current system

Donors can offer any kinds of donations to either an individual recipient or to an organization and hospital.

The patients are given momentary treatment to keep them stable as they wait for feedback from the doctors.

The patients are referred to the best hospitals by the Ugandan doctors so they can go get their treatment done which in the end saves them time for looking for a hospital when they travel abroad.

4.2.3. Weaknesses of the current system

Uganda still lacks facilities to diagnose many diseases, so the process of transplantation is undertaken by doctors abroad after referral from the doctors in Uganda. Some patients lose their lives because they cannot afford the expenses of going abroad. The entire process of testing and evaluation takes really long leading to intense and severe pain for the patients.

4.3.   System Analysis

This section contains findings from research, system, functional and non-functional requirements. In addition, it also presents a discussion of user requirements, functional requirements, non-functional requirements, and system requirements which covers both software and hardware requirements. This section describes the process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. It is conducted to analyze, interpret data from the field and presentation results.

4.4.   Findings from our research

We collected data using a Google forms tool that consisted of both open and closed-ended questions. The primary outcome of interest was the willingness of caregivers to donate a kidney to a patient with ESRD, measured as a binary outcome, namely yes and no. We asked the caregivers the question: *How would you rank your willingness to donate a kidney?*

The responses were either "I am willing to donate my kidney" or "I am not willing to donate my kidney". Each of these responses was followed by a question regarding the rationale. We also asked the participants: whether they have heard of any organ donation system in Uganda before and its name if it exists, whether they believe that organ donation can save lives, what they think is the most donated organ and whether they can donate any of their internal organs to any dying person.

Furthermore, we asked them whether they can donate to their relatives, what they think about organ donation after death, whether organ donation is against their religion and why and whether organ donation should be free.

In addition to the questions, we asked what they think are the challenges of organ donation in Uganda and their solutions plus if an Organ Donation, Fundraising and Transplant Tracking system is put in place would they interact with it? Demographics of the answers provided by the caregivers represented in percentages.

This shows the percentage of people that have heard about organ donation depicted by the color blue and the red depicts those that have not.
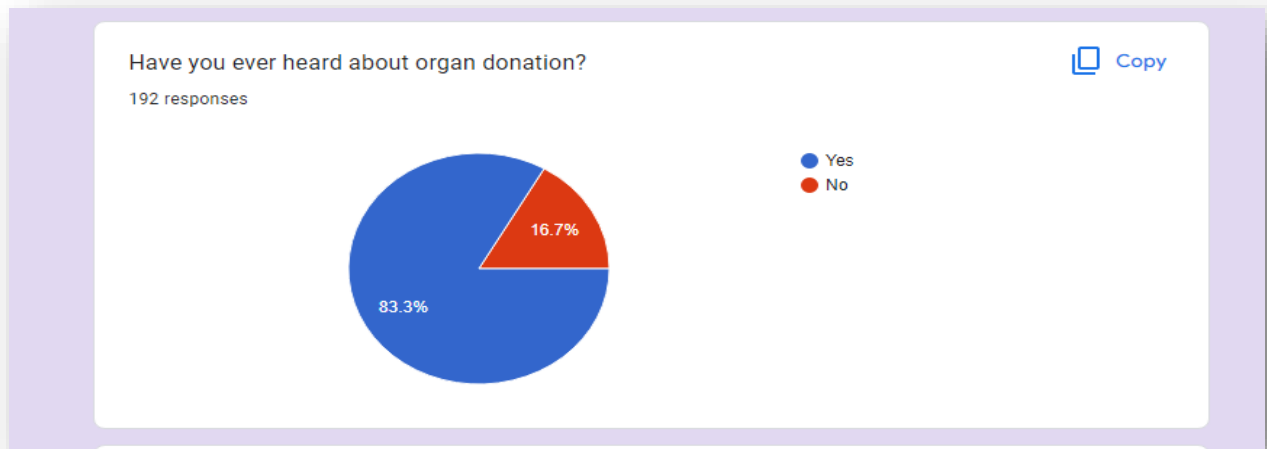

Figure 4.1: shows Reponses to the question "have you ever heard about organ donation?

A big percentage of the population replied with yes to the question "Does organ donation really save lives"
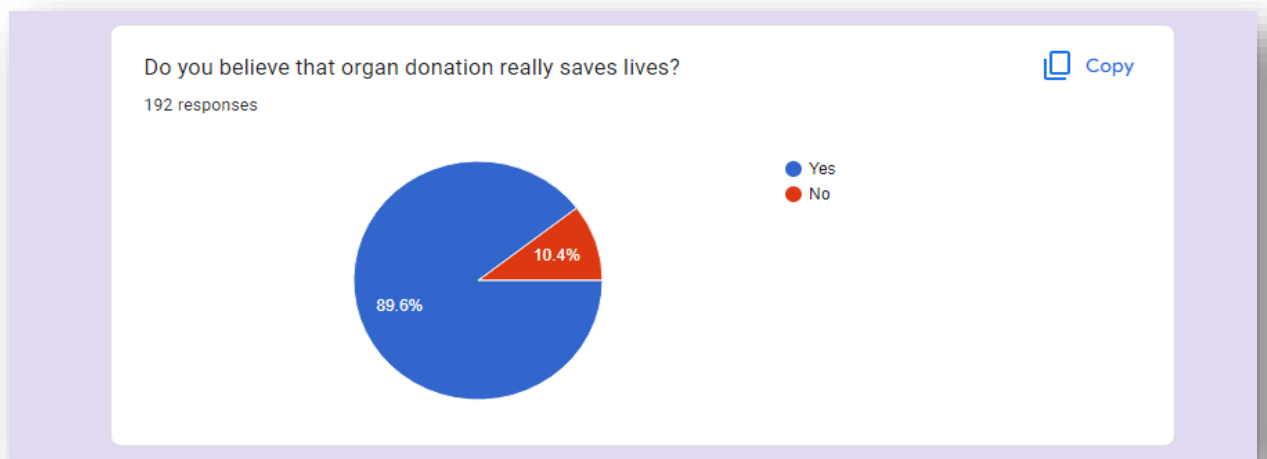

Figure 4.2. Shows Response to does organ donation really save lives?

As seen below, the greater percenatge of the population has not heard of any other organ donation and transplant tracking system as such in Uganda.
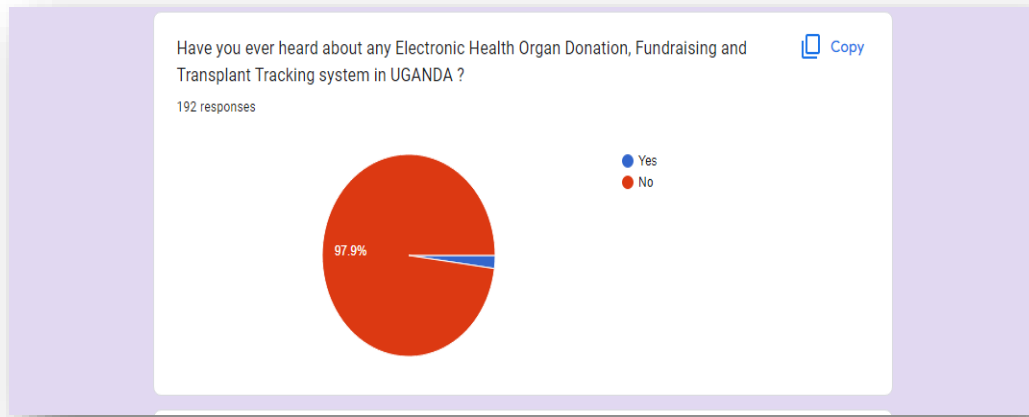
Figure 4.3: shows Responses to the "have you ever heard about organ donation?"

This pie chart shows the greater percentage of the population saying "yes" to the Organ Donation and Transplant Tracking system solving some organ donation challenges
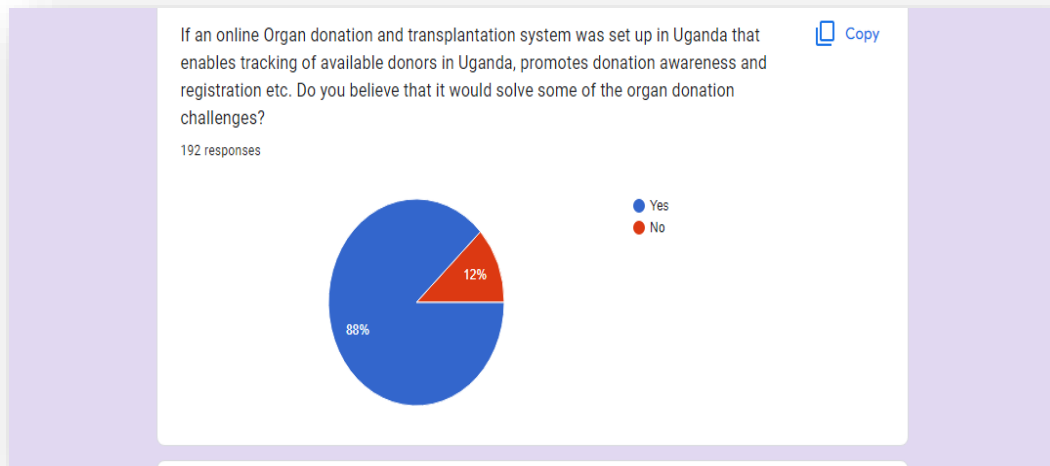

Figure 4.4: shows the response to "do you believe organ donation would save live?"

For a few of the questions like should organ donation be free, various answers were availed for people to pick from and we have the bigges saying "yes".
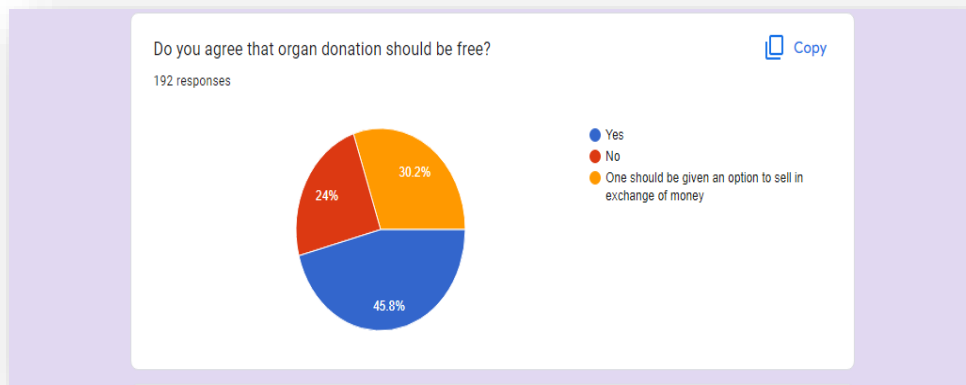
Figure 4.5: shows the responses to the question "Do you agree that organ donation should be free?"

4.5 Software specification

These are the software packages that we used in the development of an Electronic Health Organ Donation and Fundraise Tracking system and they include:

1) **VISUAL STUDIO CODE:** This is a text editor used for developing in many programming languages.

2) **HTML**: For designing the structure of the web system.

3) **JAVASCRIPT:** This is the programming language we used to capture data and form the functionality of the system.

4) **PHP**: we used this General-purpose scripting language that we used to develop the dynamic and interactive system.

5) **MATERIALIZE FRAMEWORK:** For front end design.

6) **MySQL and APACHE under xampp:** We used the language to set up our system database and server to host our system locally.

7) **CSS** and **BOOTSTRAP** for cascading stylesheets.

8) Google Chrome was the browser we used

9) We used Windows 10 Operating system

4.6 Hardware specification

The system required some hardware to execute some tasks and the following hardware facilities assisted us.

1) A laptop with at least 2GB of ram and above

2) The hard disk of 10GB space and above.

3) The processor of Intel Pentium III and above.

4) And smartphones both apple and android.

5) Processor speed of 800MHZ and above.

4.7 User requirements

The researchers interviewed the intended users of the system and collected first-hand information about what the expected features of an Electronic Health Organ Donation and Fundraise Tracking system and the following were the findings:

1) A system that is easy to learn and use.

2) A system that stores data timely and accurately.

3) A system that is fast, flexible and convenient.

4) A system that restricts access to information to only authorized personnel.

5) A system that provides attractive interfaces with easy navigation throughout it.

6) A system that has an element of error validation.

Therefore, the intended users of the system only need to have minimum computer skills and no need of specialized technical knowledge to use the Electronic Health Organ Donation and Fundraise Tracking system. Therefore, the user requirements also include; Functional and non-functional requirements.

Donors. These have free access to the system and they can fundraise without logging on to the system and their details are still captured by the organization.

4.7.1   Functional requirements

Functional requirements capture the intended behaviour of an Electronic Health Organ Donation and Fundraise Tracking system , which include the following:

1) The system should enable a user to sign up, login.

2) The system should enable the Patients see other patients stories and so will the donors

3) The system should enable the patient to request an organ.

4) The system should enable the donor to view patients in need of organs and donate organs,blood cells, tissues basing on organ type and blood group.

5) The system should enable the donor to donate cash through the online transaction app(Olycash) and see the schedule.

6) The system should enable patients donate cash to other patients through the online transaction app(Olycash) and see the schedule.

7) The system should track number of organs for donation available in the hospital.

8) The system should display tracked organs in a pie chart onto the admin dashboard.

9) The system should track the number of donors and patients who register on the system and display them in form of a bar graph in the admin dash board.

10) The system will allow direct consultation through whatsaap and telegram on both the patients' and donor's panel.

11) The system should enable the donor to check activities such as last donation, number of donations made, donations accepted, donations rejected, pending donations,fundraise events etc.

12) The system shold enable patients see requests made ,pending requests ,requests rejected and requests accepted.

13) The systems should enable users to see the fundraising part whether signed in or not.

4.7.2 Non-functional requirements

Non-functional requirements are requirements which specify the criteria that can be used to judge the operation of a system. Thus, an Electronic Health Organ Donation and Fundraise Tracking system should do the following:

1) Security: Each user is required to log in. Thus, it should prevent unauthorized access to the system with user authentication.

2) Reliability: It should have no downtime and it should be able to handle multiple concurrent users.

3) Ease of use: The general and administrative views should be easy to use and intuitive.

4) Performance: It should have a quick response time.

5) Scalability: It should have a database that can handle large amounts of data and also be able to expand in future.

4.8 System design

The researchers modelled the processes of the system using Data Flow Diagrams (DFDs), and performed data modelling using Entity Relationship Diagrams (ERDs). This section includes the system architecture, process model and data model of the Electronic Health Organ Donation and Fundraise Tracking system.

4.8.1   Data Flow Diagrams

Data flow Diagrams (DFDs) were used to illustrate the flow of information in the Electronic Health Organ Donation and Fundraise Tracking system.

A data flow diagram shows the way information flows through a process or system. It includes data inputs and outputs, data stores, and the various sub processes the data moves through (Joel, 2019).

Symbols used in process modelling

A rectangle represents an external data

Process

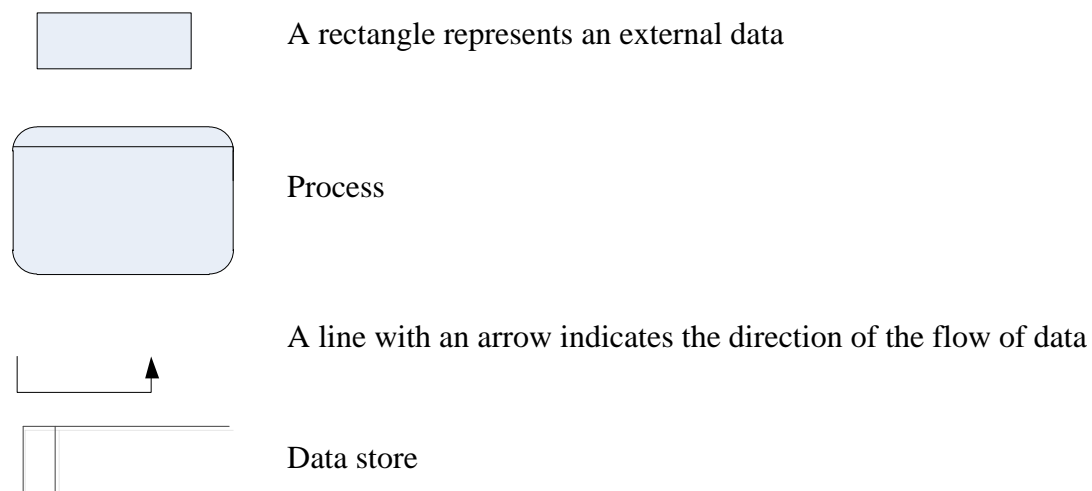A line with an arrow indicates the direction of the flow of data

Data store

Figure 4.1: Symbols used in process modelling-Yordon

1) Context diagram of the Electronic Health Organ Donation and Fundraise Tracking system

Context diagrams show the interactions between a system and other actors (external factors) with which the system is designed to interface (waterloo, 2019).

A Context Diagram represents all external entities that interact with that system (Pringsewu, 2018). It is a simple data flow diagram that shows an overview of an Electronic Health Organ Donation and Fundraise Tracking system , its boundaries, the external entities that interact with it and the major information flows between external entities and the system.
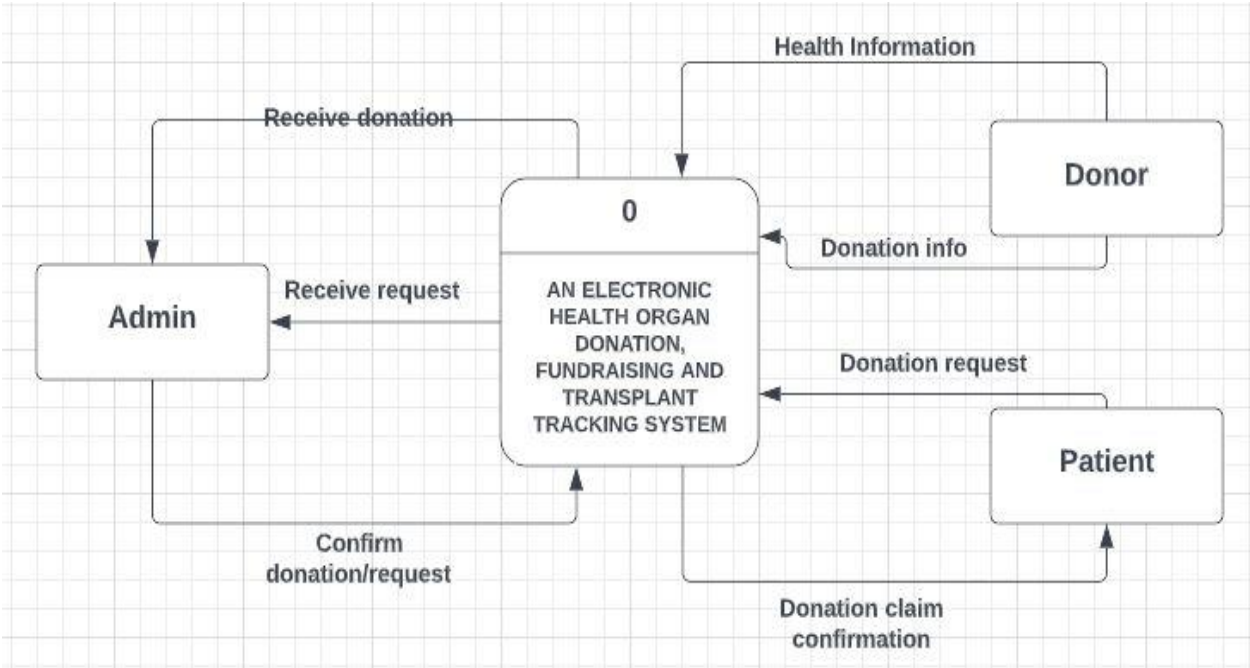
Figure 4.2: Context diagram of an Electronic Health Organ Donation and Fundraise Tracking system

Figure 4.3:A Level 0 diagram of an Electronic Health Organ Donation and Fundraise Tracking system

4.8.2 Entity Relationship Diagrams

An entity-relationship diagram (ERD), also known as an entity-relationship model, is a graphical representation that depicts relationships among people, objects, places, concepts, or events within an information technology (IT) system (Jacqueline, 2019).
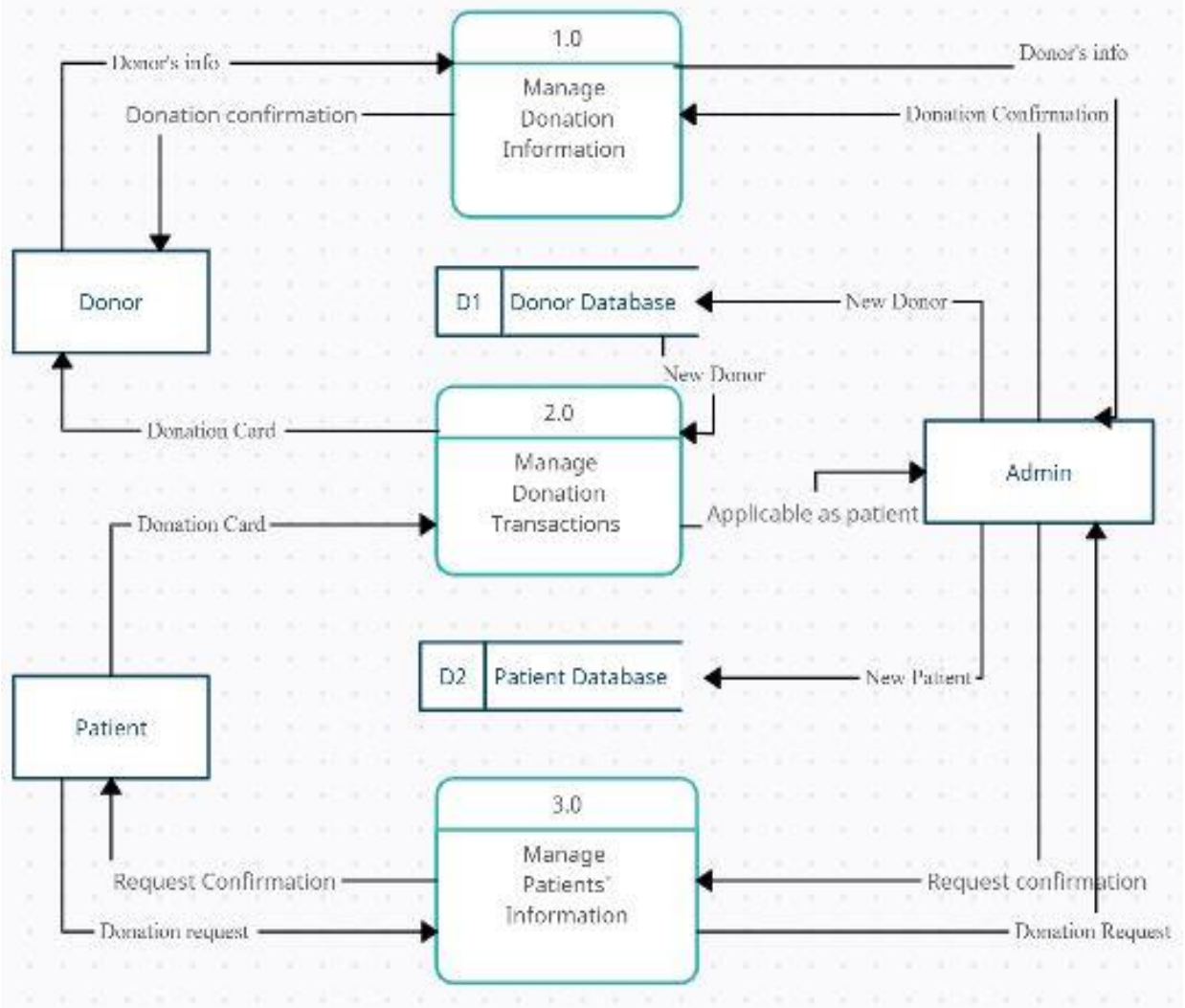
AN ELECTRONIC HEALTH ORGAN DONATION, FUNDRAISING AND TRANSPLANT TRACKING SYSTEM

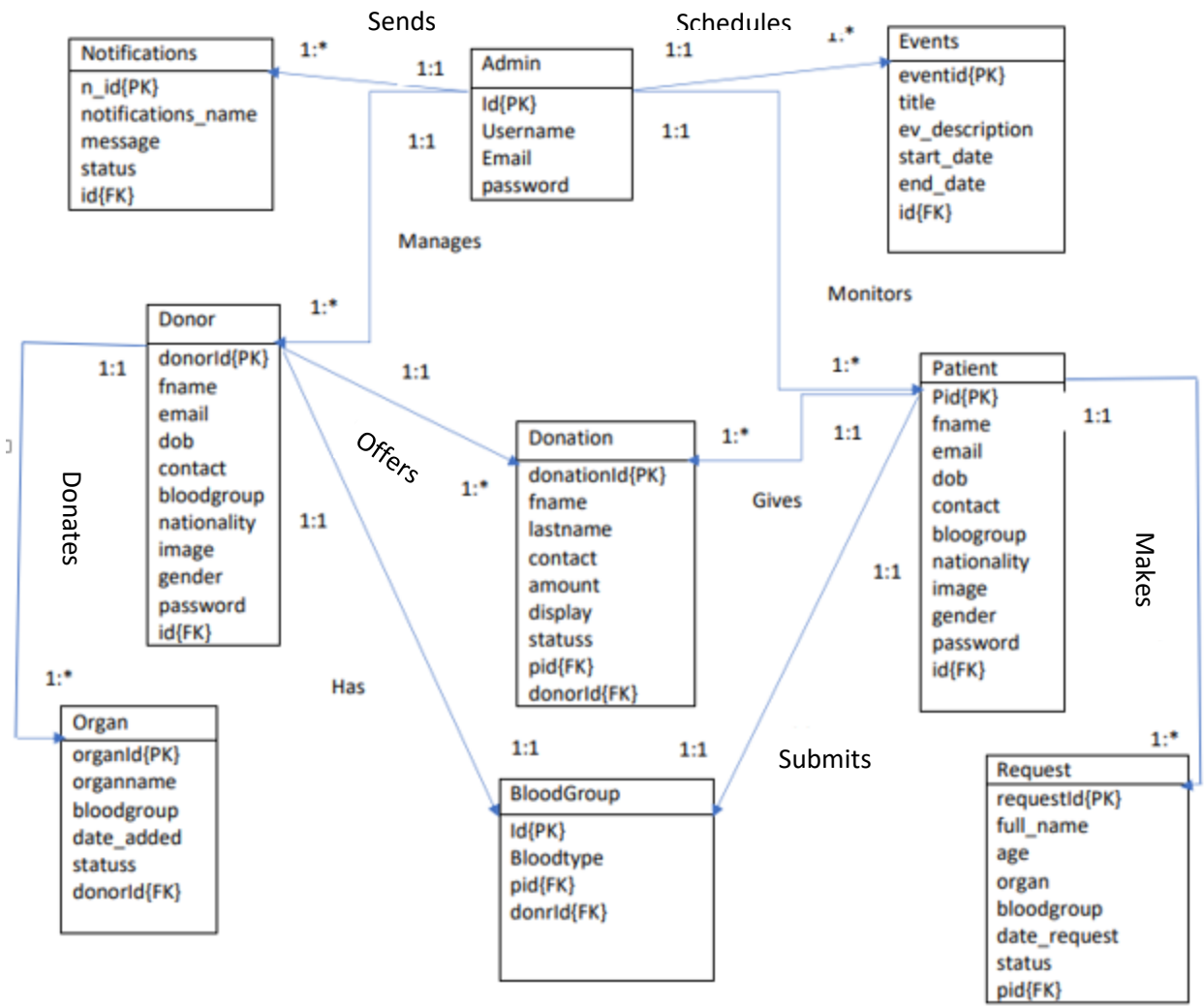*Figure 4.4: An Entity Relationship Diagram of an Electronic Health Organ Donation and Fundraise Tracking system.*

4.8.3 Data Inputs (System forms)

In fulfillment of the objective which was to develop an Electronic Health Organ Donation and Fundraise Tracking system that helps to reduce the delay in organ donation delivery within Uganda, the following forms were designed to capture user data.

CHAPTER 5: SYSTEM IMPLEMENTATION, TESTING, AND VALIDATION

5.1. Introduction

The chapter defines the implementation of the design presented in chapter five to meet the requirements of the system as well as testing and validation of the system.

5.2. System implementation

Technologies of different categories were used during the implementation of this system as they are further explained below.

1) Login Form

Using the Login form the user can enter a user name and password assigned by the system administrator. If the password is correct the user can then access the system information which varies for the different user levels.

Figure 5.1: Login Form 1

1) This is the home page where patients and donors sign up or Login
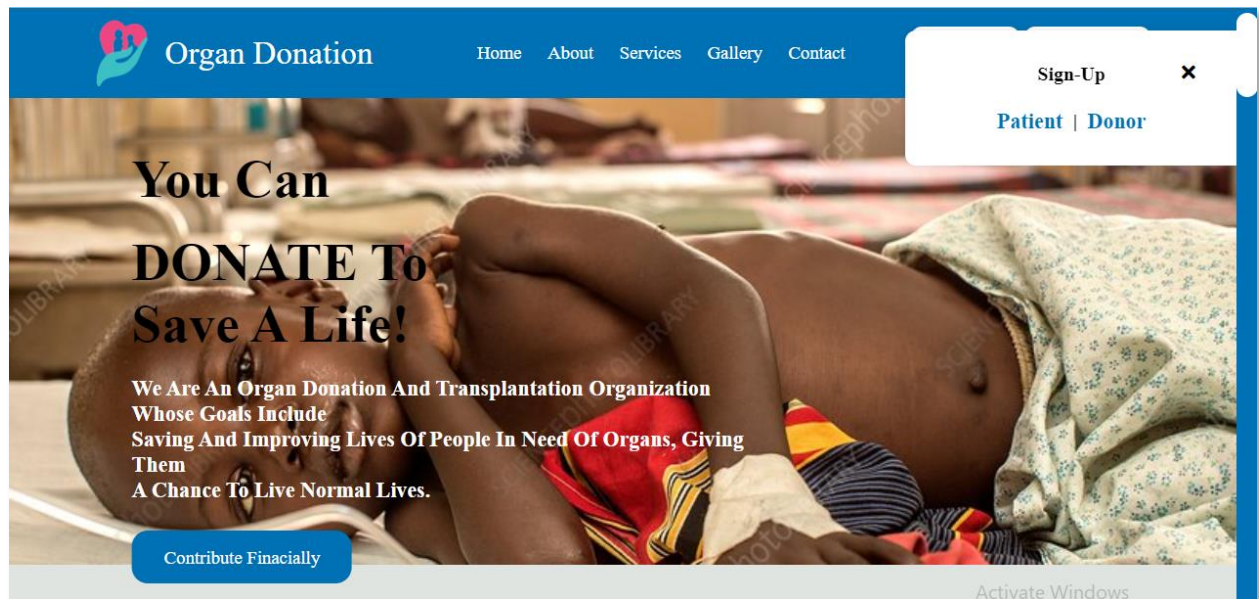
1) **System administrators**

When logged in as a system administrator, one can be able to schedules and manage Events, view and delete patients, donors on the system, manage organ requests and donations, update request history, updates oragan stock and make notifications.

The interface below is of the dashboard where we can see the patients, donors and the organs in stock
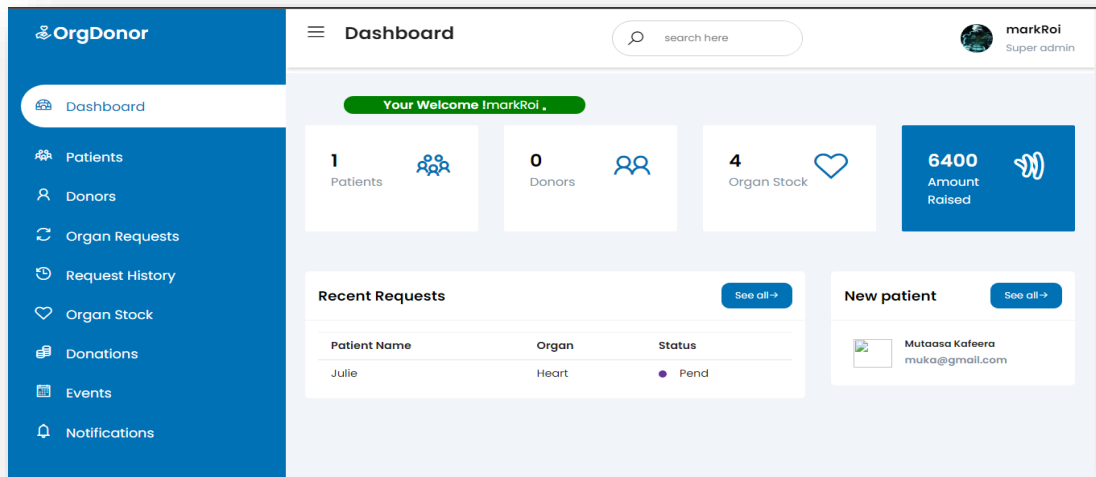
Figure 4.6.1: Admin Dashboard 1

5.2.1. System technologies

The Electronic Health Organ Donation and Fundraise Tracking system was realized with the aid of MYSQL which is a relational database management system. The choice for MYSQL was based on the ability to execute on all platforms including LINUX, and WINDOWS. MYSQL is also scalable it can handle multiple user connections. MYSQL is as well an open-source software.

Hypertext Markup Language (HTML) and Bootstrap was used as a language that specified the structure of the document retrieval across the internet using browser programs on the World Wide Web.

Java scripts together with PHP were used as scripting languages that were embedded with HTML to allow interactivity and cascading style sheets (CSS) for presentation and formatting. Also Materialize framework was used for front end development.

MySQL and Apache under xampp: We used the language to set up our system database and server to host our system locally.

Most of the software used in the system implementation was chosen based on the fact that it was cheap, readily available, and supported in rapid development.

5.3. System functionality

5.3.1 Authentication.

The system allows users (admins) to log in before accessing the Dashboard page to carry out the administrative roles and validation of the entered credentials goes on to ensure all fills have been filled. Sessions are fetched basing on the email entered at the login/ register form.

5.3.2. Online money transaction.

The system allows the users to make money donation transactions online using the Olycash app. The Olycash Application Programming Interface (API) allows potential donors offering monetary funds to send them directly to the recipient.

5.3.3. Donor contacts and activities management.

The system captures donor details, donations made and manages them in the various forms provided for example the event management interface displays the events and their scheduled dates.

5.3.4. Online Information about donation.

The system provides vast and elaborate information about the entire ordeal of organ donation in terms of why organ donation is carried out/ how it works, and who can donate.

5.4. System testing.

This was done through the deployment of the Electronic Health Organ Donation and Fundraise Tracking system to discover its weaknesses and strengths, thereby concluding about its compliance with its intended specification and functionality.

The following testing strategies were deployed:

5.4.1. User testing.

A group of target users was selected to examine the system functionality and gave us feedback as shown in table 5.1 below.

Table 5.1: Showing the feedback from users after using the system

	User testing question	1	2	3	4	5
1	The system enables donors to donate money, and organs					✓
2	The system enables donors to monitor the progress of their donations					✓
3	The system enables donors to view other peoples' donations if they select public.					✓
4	The system enables donors to search for their donations and names.					✓
5	The system enables donors to submit their details before donating.					✓
6	The system enables administrators to approve pending donations after receipt.					✓
7	The system enables administrators to assign account type to the users.					✓
8	The system allows donors to donate using mobile money through the Olycash app					✓

5.4.2. Unit testing.

Individual units or components of the system were checked to ensure they are fully functional units before integrating them. This was done by examining each unit and that it performed as exactly intended.

Test Case ID	LOS_002	Test Case Description	Test the log in forms			
Created By	Group 2	Reviewed By				
Tester's Name	Mark	Date Tested	30-SEPT-2022	Test Case (Pass/Fail/Not Executed)	Pass	
S #	Prerequisites:		S #	Test Data		
1	Data base A connected login form to the database		1	Log in successful		
w						
Test Scenario	Test to see whether one with the right credentials can log in successfully.					
Step #	Step Details	Expected Results	Actual Results	Pass / Fail / Not executed / Suspended		
1	Input in the right credentials in the log in form	Log in successfully	As Expected	Pass		

5.4.3. System testing.

Under system testing, performance testing was done after the system was coded to see its responsiveness and stability under a particular workload. This was done by fetching loads of data from the database and see the time taken to fetch and whether the data is actually fetched.

Test Case ID	LOS_002	Test Case Description		Test the system performance			
Created By	Group 2	Reviewed By					
Tester's Name	Teddy Rhonnie	Date Tested		2-OCT-2022		Test Case (Pass/Fail/Not Executed)	Pass
S #	Prerequisites:			S #	Test Data		
1	Database Pages links			1	Fetching from the database is fast Pages connect through links		
w							
Test Scenario	Test to see whether system f Performance is good.						
Step #	Step Details	Expected Results		Actual Results		Pass / Fail / Not executed / Suspended	
1	Go to the system and check whether the tables and data being fetched is showing. Click on the links to	System performance is good. Takes less time to fetch data from the database.		As Expected		Pass	

5.4.4. Intergration testing.

All the links were checked to see whether they actually link to the directed pages and all the individual units of the system were integrated and tested as a whole.

Test Case ID	LOS_002	Test Case Description	Test the functionality of the links			
Created By	Group 2	Reviewed By				
Tester's Name	Juliet Brian	Date Tested	20-SEPT-2022	Test Case (Pass/Fail/Not Executed)	Pass	
S #	Prerequisites:			S #	Test Data	
1	Linked pages links			1	The functionality of the links	
w						
Test Scenario	Test to see whether the links can take you from one page to another					
Step #	Step Details	Expected Results		Actual Results		Pass / Fail / Not executed / Suspended
1	Take the cursor to the link and click to see whether the link takes you to the directed page	Pages are linked correctly		As Expected		Pass

5.4.5. Usability testing.

Usability testing was done by our fellow students under different options to assess our system usability and their comments were; "*The system is easy to use but the pages arent intergrated well,some take long to respond.*"

So we sat down as a group and rectified the problems found and we gave them the system to retest until they couldn't find any problems and navigation in the system.

5.5. System validation.

System validation is concerned with ensuring that data entered into the systems meets predefined formats with defined input criteria. It was done to ensure that the data entered and retrieved is valid.

CHAPTER SIX: SUMMARY, LIMITATION, CONCLUSION, AND RECOMMENDATIONS

6.1. Introduction

This chapter provides a summary, limitation, conclusion, and recommendations of an Electronic Health Organ Donation and Fundraise Tracking system

6.2. Achievements

Organ Donation System has ensured sufficient donation delivery and it has also enabled easy accountability for the donations received by the admin in a given period.

The system shall be able to access the payment gateway after donation.

6.3. Challenges

Electronic Health Organ Donation and Fundraise Tracking system is intended to be hosted on the internet where it can be accessed by the public. As such, it requires an internet connection.

The system shall not be able to function if the server stops running. The server should always run when the system is loading.

6.4. Limitation of the study

Since there is no working system in Uganda to handle Organ Donation and Tracking and hence we had to carry out most of the research basing on systems in other countries.

6.5. Recommendations

Electronic Health Organ Donation and Fundraise Tracking system is highly recommended for use by health facilities because it would reduce the inefficiency in donation delivery to the people in need. It is also important to train and encourage users to get accustomed to and Donation and Transplant Tracking System. This being a new system, some of the users (donor and admin) may need to fully understand how the system functions.

6.6. Conclusions

The core reason for the establishment of an Electronic Health Organ Donation and Fundraise Tracking system was to reduce the inefficiency in organ availability, delivery and tracking in Uganda. Therefore, the technologies used should support the core objective of the system if it is to remain relevant to the users. A lot still needs to be done in the IT department to make available technology effective. Management has to keep updating the hardware and software requirements of the system; Information Technologies and computer systems need to be sustainably upgraded as more software is introduced in today's IT market.

Our research acknowledges the fact that the system is not existing as per our research in Uganda today.

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APPENDICES

Appendix 1: Interview guide

<u>**INTERVIEW GUIDE**</u>

1. How would you explain organ donation in simple terms?

   "Organ donation is giving some one an organ who is in need of it."

2. How can one become a donor?

   "I really don't know because is its rare in our country Uganda."

3. Are you (registered) a donor?

   "No"

4. Where do potential donors register from?

   "I can't tell"

5. How many people do you think are on the registered donors list Uganda? Make an estimate

   "I think 20."

6. At what age is a person considered legible to become a donor?

   "I think 18 years of age."

7. What organs can one donate while he/she is still alive?

   "A kidney because a person has two."

8. Can a donor choose to sell any of his/ her organs instead of donating it for free?

   "Actually, most people would sell instead of donating."

9. How many patients do you think are in need of organ transplant in Uganda? Make an estimate

   "200,000people."

10. We know that organ transplant is sometimes a solution to internal organ failure, what are some of the causes of organ failure?

    "Smoking and imbalanced deity."

11. Do donors and recipients always get to meet physically before the procedure?

    "No, I don't think so."

12. What organ is needed most?

    "Heart."

13. Has Uganda ever performed any organ transplant?

    "No."

14. When was the first transplant? Where?

    "None."

15. Which organ was it?

    "None."

16. In 2021, and Organ donation and Transplant Bill was approved. What guidelines are meant to be followed Uganda?

    "I can't tell."

17. How many organ transplant centers are there in Uganda? What are their names and location? (Or are there any under construction)

    "None."

18. What are some challenges to organ donation and transplantation?

    "Possibilities of infections due to lack of qualified machines, Transplant rejection and Death."

19. What are some of the solutions you could recommend?

    "Import good machines from abroad to help in the transplantation session."

20. Do you know any online Electronic Health Electronic Health Organ Donation and Fundraise Tracking system / website? What is it called?

    "No, I haven't."

21. Have you ever interacted with it?

    "No."

22. Is there any online website or system about organ donation, procurement and transplantation in Uganda? Name if it is there

    "I haven't heard of any."

23. If one or more systems are put in place in Uganda that tracks available donors and organs, do you think they would solve some of the challenges to organ donation and transplant?

    "Yes."

24. Would you interact with it? Would you also recommend it to health organizations?

    "Yes, I would interact with it and recommend it."

QUESTIONNAIRE ABOUT AN ELECTRONIC HEALTH ORGAN DONATION AND
FUNDRAISE TRACKING SYSTEM

It is my consent to complete the following questionnaires with the assurance that the information provided herein shall be treated confidentially and will be solely used for the purpose of this survey.

<u>INSTRUCTIONS</u>

- Tick or make a diagonal cross inside the checkbox ☑ next to the desired option.

1. Have you ever heard about organ donation?

   ☐ Yes   ☐ No

2. Organ transplant is a solution to fixing internal organ failures. What do you think are the causes of internal organ failures?

   a)………………..................   c)……………………………
   b)………………..................   d)……………………………

3. Do you believe that organ donation really saves lives

   ☐ Yes   ☐ No

4. Would you donate any of your internal organs to any dying person when still alive?

   ☐ Yes   ☐ No

5. Would you donate to a relative?

   ☐ Yes   ☐ No

6. Which of the following best describes how you personally feel about organ donation after death?

Please select one answer only

☐ I definitely want to donate all of my organs after death if possible

☐ I definitely want to donate some of my organs after death if possible

☐ I would consider donating all of my organs after death

☐ I would consider donating some of my organs after death

☐ I don't know if I want to donate my organs after death

☐ I definitely don't want to donate my organs after death

7. Do you think organ donation is against you religion or faith?

☐ Yes   ☐ No

If you think organ donation is against your religion / faith. Which of the following describe how you're aware of this? Select all that apply

☐ I discussed it with a religious leader / clergy

☐ I discussed it with friends and family of the same religion / faith

☐ I did my own research

☐ From my own interpretation of my religion / faith's scripture

☐ I've heard a religious leader / scholar speaking about it

☐ I just know it's against my religion / faith

☐ I think it's against my religion / faith but I would need to look into it more

☐ I don't know for sure it's against my religion / faith

☐ Don't know

Specific reason:

………………………………………………………………………………………………

………………………………………………………………………………………………

8. Do you agree that organ donation should be free?

☐ Yes   ☐ No   ☐ One should be given an option to sell in
                                          Exchange of money

Why?

………………………………………………………………………………………..

………………………………………………………………………………………..

9. Do you know any person that has ever donated an organ or is thinking about donation an internal organ?

☐ Yes   ☐ No

10. Below are a number of things that people have said about organ donation. For each one, we would like you to say whether you think it is true or false

☐ To be an organ donor, you have to donate all of your organs

☐ Fewer than 5000 people each year die in circumstances where they can donate their organs

☐ Fewer than 1500 people each year donate their organs

☐ People who have donated their organs can't be viewed after death or have an open casket

☐ There is an upper age limit of 60 for donating organs

11. What do you think are some of the challenges of organ donation in Uganda?

………………………………………………………………………………………….

………………………………………………………………………………………….

…………………………………………………………………………………………..

12. Suggest some of the possible solutions.

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

13. Before today, were you aware of any Electronic Health Electronic Health Organ Donation and Fundraise Tracking system anywhere in the world?

☐ Yes   ☐ No

What's the name of that system?

…………………………………………………………………………

14. Have you ever had about any Electronic Health Electronic Health Organ Donation and Fundraise Tracking system in Uganda?

☐ Yes   ☐ No

15. If an online Electronic Health Electronic Health Organ Donation and Fundraise Tracking system was set up in Uganda that enables tracking of available donors in Uganda, promotes donation awareness and registration etc.

Do you believe that it would solve some of the organ donation challenges?

☐ Yes   ☐ No

16. Would you interact with the system?

☐ Yes   ☐ No

Appendix 3: A pie chart showing responses to the question "Do you think organ donation is against your religion or faith?"
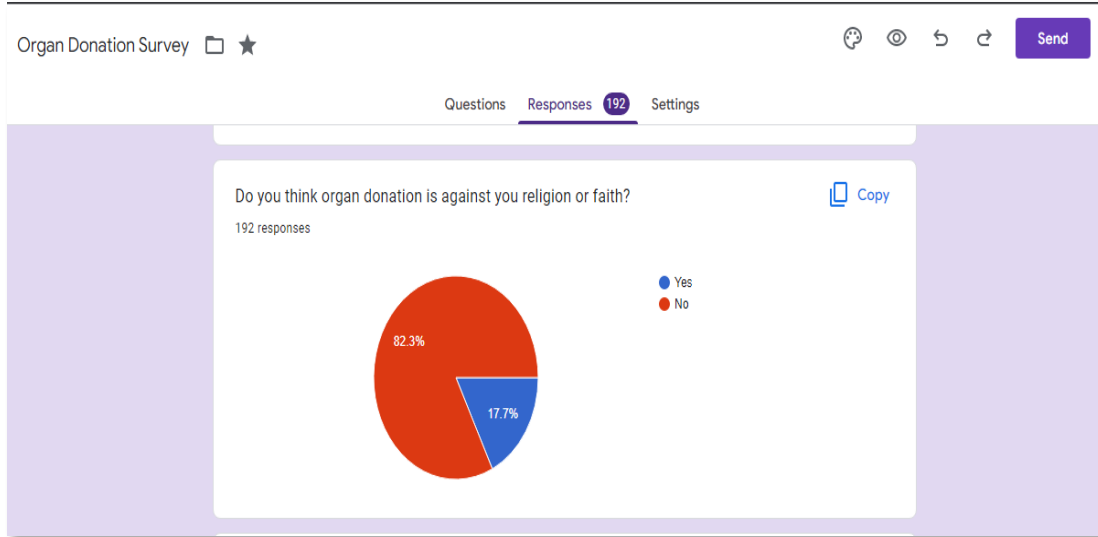
Appendix 4: A bar graph showing responses to the question "Do you think organ donation is against your religion or faith?"
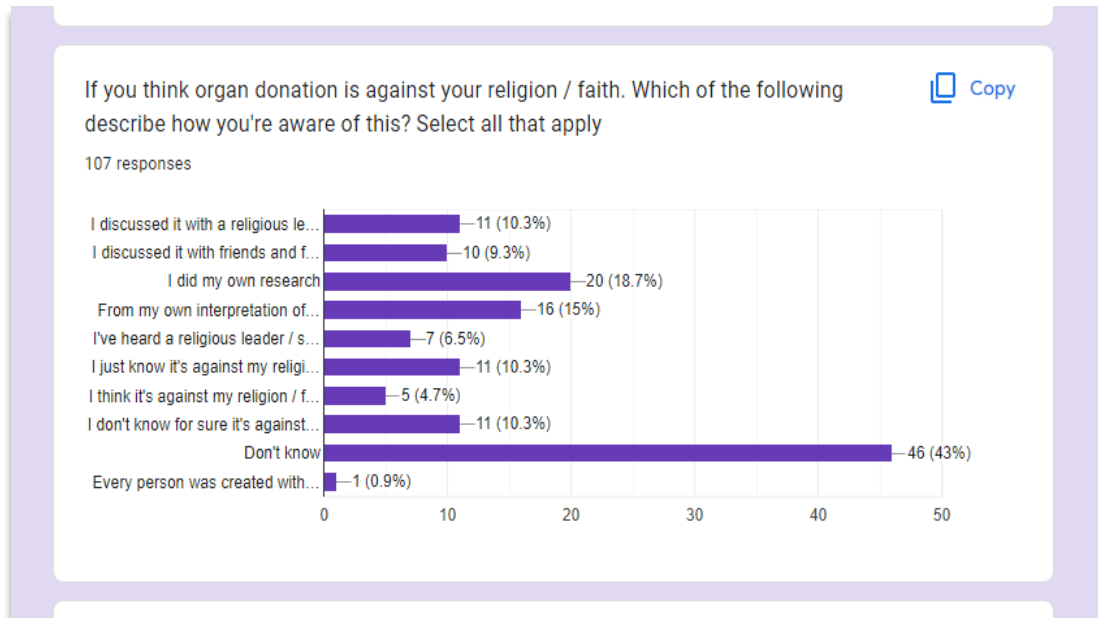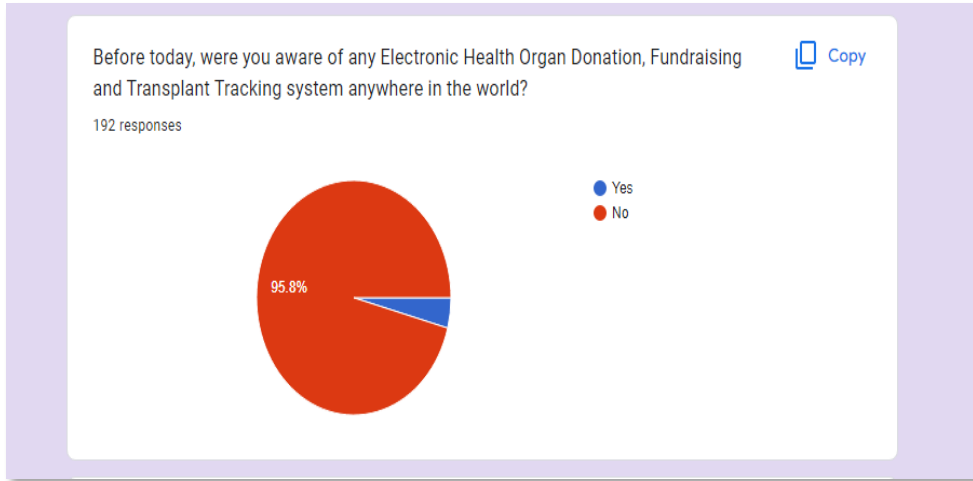
Appendix :5 A pie chart showing responses to the question "Do you know any person that has ever donated an organ or is thinking about donating an internal organ?"
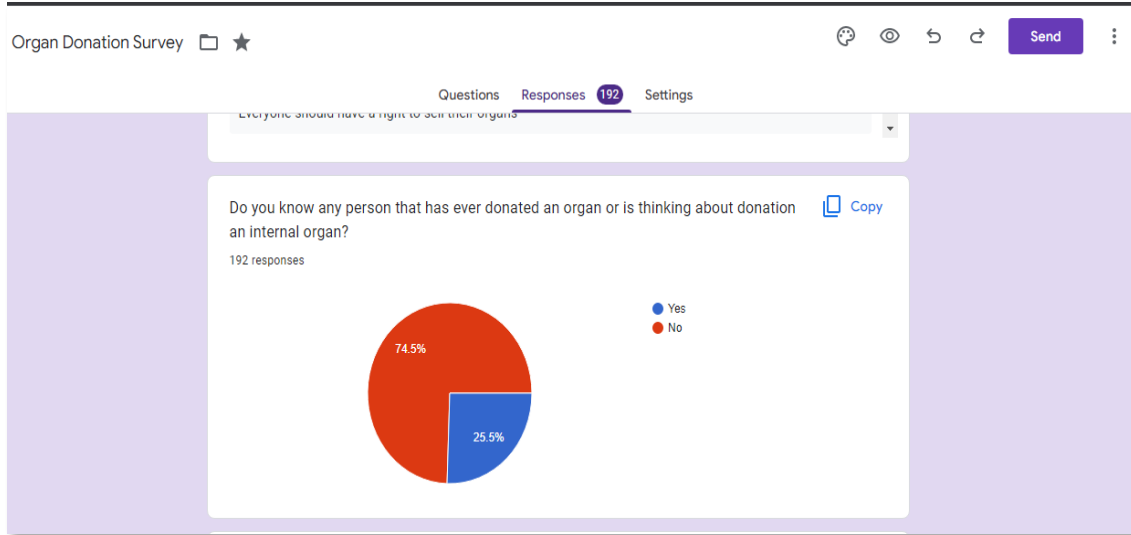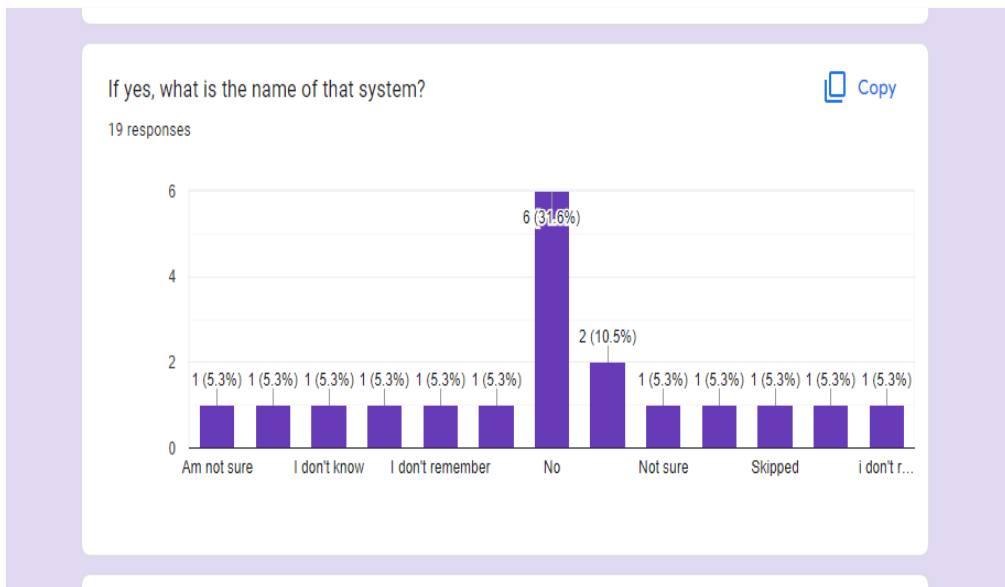

Appendix :6 A Bar graph showing responses to the question "Do you know any person that has ever donated an organ or is thinking about donating an internal organ?"
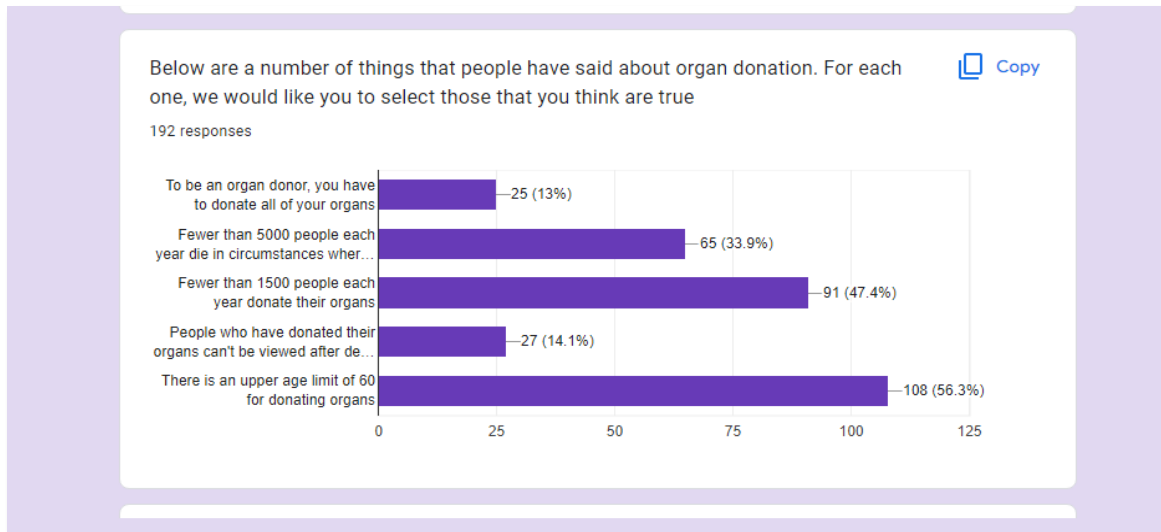
Appendix: 7 A pie chart showing responses to the question "Before Today, where you aware of any Electronic Health Organ Donation and Fundraise Tracking system anywhere in the world?"

Before today, were you aware of any Electronic Health Organ Donation, Fundraising and Transplant Tracking system anywhere in the world?

192 responses

- Yes
- No

95.8%

Appendix:8 A Bar graph showing responses to the question "Before Today, where you aware of any Electronic Health Organ Donation and Fundraise Tracking system anywhere in the world?"

If yes, what is the name of that system?

19 responses

6 (31.6%)

2 (10.5%)

1 (5.3%) 1 (5.3%) 1 (5.3%) 1 (5.3%) 1 (5.3%) 1 (5.3%)   1 (5.3%) 1 (5.3%) 1 (5.3%) 1 (5.3%) 1 (5.3%)

Am not sure   I don't know   I don't remember   No   Not sure   Skipped   i don't r...

Appendix:9 Donors panel showing organs donors can donate.