UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

The Use of ICT for Blood Donation:

A Donor Information Needs Driven System to Address Kenya's Low Blood Donation Rates

BY

SALOME IRERI

P51/65164/2013

Supervisor

Prof. Peter Waiganjo Wagacha

November, 2014.

Submitted in partial fulfillment of the requirements for the Degree of Master of Science in Applied Computing of the University of Nairobi

DECLARATION

This research project is my original work and has not been presented for award of any degree in any University

Name: Salome Ireri

……. ……
Signature Date

This research project has been submitted for examination with my approval as University Supervisor

Name: Prof. Peter Waiganjo Wagacha

…… ……
Signature Date

ABSTRACT

The gap between demand and supply of blood is continuously widening as the population increases. This is of great concern in Kenya where blood donation figures are below the World Health Organization's recommendations. A random cross-sectional survey involving 224 respondents was conducted in and around Nairobi. The objective of this study was to elicit donor information needs to enable the improvement of donor recruitment and retention strategies through the use of ICT based tools.

63.8% of respondents had never donated blood and only 4.9% were regular donors. Only 19 of the 81 donors had been contacted by the Kenya National blood Transfusion Service. 71.4 % of all respondents indicated that receiving SMS and emails with information on blood donation dates and venues would be quite useful, while 79% would welcome educative information on blood donation.70.1% of respondents suggested that increased awareness on donation dates and venues and increased donor education would improve donor participation. This survey identified information gaps present in the current National Blood Transfusion Service systems and in Kenya in general. There is very little use of ICTs to help improve blood donor participation.

This research project aimed at not only identifying these gaps but also creating ICT based ways of filling in these gaps. A donor information needs oriented prototype system was therefore designed and developed. It was then tested with the aim of finding out if it was meeting the identified donor information needs.

85% of the respondents of this test strongly agreed that they appreciate receiving a donor registration confirmation and a thank you note via SMS immediately after donation. 75% of the respondents indicated they very much welcomed receiving SMS notifications with useful information on when and where to collect their donor card and blood test results. While over 70% of the participants indicated that they found SMS messages with donation dates and venues and educative information useful and motivating. 55% strongly agree that the probability that they are more likely to donate after receiving the donation notifications and educative information is high. Based on these test results, the registered donors appreciate receiving notifications and educative SMS messages through this system and are now more likely to attend donation drives and donate and share the knowledge they receive with friends and family.

DEDICATION

This research project is dedicated to my family, which has supported me throughout this research period. To my father and mother who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

God Almighty for the strength and grace to accomplish the much I have throughout this master's course.

My family whose love and steadfast support throughout the project was greatly needed and deeply appreciated.

My supervisor Prof. Peter Waiganjo has been the ideal project supervisor. His sage advice, guidance, insightful criticisms and patient encouragement aided carrying out this research project in innumerable ways.

My classmates and friends who shared ideas and provided assistance during this project.

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

BBMS:	Blood Bank Management System
BDMS:	Blood Donor Management System
CDC:	Centre for Disease Control
GDBS:	WHO Global Database on Blood Safety
HDN:	Hemolytic Disease of the Newborn
HIV:	Human Immunodeficiency Virus
ICT:	Information Communication Technology
IICD:	International Institute for Communication and Development
KNBTS:	Kenya National Blood Transfusion Service
KRC:	Kenya Red Cross
MNBTS:	Malawi Blood Transfusion Service
NBA:	Australian National Blood Authority
NBMS:	National Blood Management System
NBTS:	National Blood Transfusion Service
RAD:	Rapid Application Development
RBC:	Red Blood Cells
RBTC:	Regional Blood Transfusion Centre
RH:	Rhesus factor
TTIs:	Transfusion-Transmissible Infections
VNRBD:	Voluntary Non Remunerated Blood Donors
WHO:	World Health Organisation
ZNBTS:	Zambia Blood Transfusion Service

DEFINITION OF TERMS

Blood: It is a liquid substance that flows through human veins and arteries that carried and transports oxygen, nutrients and other necessary elements to tissues.

Blood Bank: This is a registry or collection data on donated blood kept by a blood transfusion center.

Blood Bank Management System: This is a computerized system designed to store, process, retrieve and analyze information concerned with the administrative and inventory management in blood bank for storage and issuance of blood.

Blood Donors: This is an individual who gives blood to be received by another individual who needs a transfusion.

Blood Donation: It is the process through which a willing individual gives blood which is received by another individual in need of a transfusion in order to manage a health condition.

Blood Donor Management System: This is a computerized system created for a blood transfusion center to enable it store, process, retrieve and analyze information on blood donors mostly based on their blood groups. It can be used to track and contact donors whenever there is need to.

Information and Communication Technology: ICT is an umbrella term that refers to devices and applications that are used to create solutions that provide access to information. ICT encompasses: radio, television, cellular phones, computer and network hardware and software, satellite systems, as well as the various services and applications associated with them, such as videoconferencing and distance learning. These ICT solutions must be tailored specifically to a particular context in order for them to be useful and give the required results.

National Blood Transfusion Service: This is the body mandated to collect and distribute blood within a country.

Screening: This is a medical process in which blood is scanned to test for diseases such as HIV, Syphilis, Hepatitis B and Hepatitis C or to find out the blood group of an individual.

Transfusion: Is the act of transferring blood from one individual to another.

Voluntary Non Remunerated Blood Donors: This is a blood donor who willing gives blood without receiving any form of payment or reward for his action.

1. INTRODUCTION

1.1 Background of the Problem

Blood transfusion saves lives and improves health and therefore contributes to the achievement of the Millennium Development Goals 4, 5 and 6. Timely access to safe blood can prevent many deaths especially in the developing world. One pint of blood (450ml) can save 3 lives while a teaspoon of blood can save a baby's life. In many developing countries, up to 65% of blood transfusions are given to children under 5 years of age. Yet these developing countries which make up more than 50% of the world's population donate less than 50% of the total donations (WHO Report, 2011).

Every day, almost 800 women die from causes related to complications of pregnancy and childbirth. 27% of these women bleed to death before, during and after giving birth (WHO, 2014). Maternal mortality in Kenya has remained unacceptably high at 488 maternal deaths per 100,000 live births, with some regions reporting rates of 1,000 death for 100,000 live births in 2008 and 2009 (UNDP, 2009) yet the country has one of the lowest blood donation rates. These deaths can be prevented with equitable access to safe blood for obstetric care but this still remains a major challenge, contributing to high maternal mortality.

The gap between demand and supply of blood is continuously widening and to bridge this gap, the World Health Organization (WHO) recommends in its Global Database on Blood Safety (GDBS) that all activities related to blood collection, screening, processing, storage and distribution should be coordinated at the national level through effective organization and a national blood policy and system. The World Health Assembly Resolution (WHA) 28·72 of 1975, set the bench mark for the development of national blood programmes, whether nationally organized, or nationally coordinated. This has led to the rapid increase in the quality, safety and adequacy of blood in both developed and developing countries (Emmanuel, 2006).

In 2001 Kenya's first ever blood policy guidelines were developed and launched and the first Regional Blood Transfusion Centre (RBTC) and national coordinating office were established in Nairobi (Oduor, 2010). The Kenya National Blood Transfusion Service (KNBTS) is the institution mandated by the Kenyan Ministry of Health (MoH) to coordinate and manage the national blood transfusion programme.

Blood has a short shelf life of 35 days and its demand is always high, therefore its supply should always be constant. This is not the case in most parts of the world. Provision of safe and adequate blood in a timely manner for use in various emergency conditions from traumas to major operations and diseases that necessitate regular blood transfusion should be an integral part of every country's healthcare sector and thus the need for a national donation and transfusion agency. This is achieved through the regular collection, screening and storage of blood obtained from Voluntary Non Remunerated Blood Donors (VNRBD). VNRBDs are the main source of blood donations and their blood is considered the safest compared to that from family/replacement and paid donors (Kimani, Mwangi, et. al., 2011). WHO aims to achieve 100% voluntary non remunerated donations by 2020. Kenya is one of the few countries in the world where this has already been achieved.

Kenya has six centralized blood banks throughout the country known as Regional Blood transfusion Centres (RBTC). All willing blood donors can walk to any of the RBTCs located in Nairobi, Embu, Nakuru, Mombasa, Kisumu or Eldoret. They can also choose to walk to any of the Provincial or District hospital-based blood banks and donate blood voluntarily. The reason for regional blood repositories is to ensure that dozens of neighboring local district hospitals are always stocked with an adequate amount of blood to meet the transfusion needs especially in the event of an emergency (Kiwanja, 2007).

Apart from collection and distribution of blood the KNBTS is also responsible for the coordination, management, monitoring and evaluation of the national blood transfusion programme, setting up blood transfusion and waste management standards to be followed by blood centres and health facilities, ensuring efficient procurement and supply chain systems for blood centres and the coordination of organizations involved in blood transfusion service provision among others.

One of the duties of a National Blood Transfusion Service (NBTS) is to recruit VNRBDs. To enable recruitment and retention of donors, awareness needs to be created on the importance of regular blood donation by those who are within the donation age limits, that is, 16 to 65 years of age and weigh more than 50Kgs. KNBTS faces several challenges one of which is inadequate funding and personnel, therefore it is unable to provide adequate public awareness and education to both donors and non donors in the country. In Kenya, awareness, mobilization and recruitment

mainly through mobile blood drives is done by Non-Governmental Organizations such as the Kenya Red Cross (KRC) and Hope Worldwide Kenya, and private associations like Community Blood Donor clubs and Pledge 25 which promotes voluntary blood donation among the youth, their mission being to increase the blood supplied by KNBTS.

KRC has for over 40 years been a key partner to the Kenyan government on blood safety contributing to the mobilization of most donors and therefore more than 50% of the blood collected annually. It has contributed to the mobilization and recruitment of VNRBDs, retention of repeat donors, infrastructural support to the government and advocacy on the blood safety policy. In 2012 KRC's focus was mobilization, recruitment and retention of VNRBDs, promotion of healthy living amongst donors and the general population and advocacy (KRC, 2014).

1.2 Statement of the Problem

Kenya faces persistent blood shortages in its blood banks due to its low blood donation rates. The minimum blood requirement need is estimated at 1% donation of the population, but less than half of this is donated in Kenya (KNBTS Report, 2010). KNBTS as of 2013 managed to collect 170,000 units of blood which is 42.5% of the 400,000 units required by the country annually (KNBTS Report, 2013).

Like many other NBTSs around the world, KNBTS lacks self-sufficiency and sustainable strategies to perform all its duties, one of which is to recruit and retain donors for the purpose of regular blood collection.

1.3 Objectives of the Study

This project aimed at developing a solution that facilitates the co-ordination between blood supply and demand. The developed solution keeps a store of registered donors which helps track regular donors and enables the blood center contact them when the need arises like when blood levels are near critical.

The Research Objectives of this project included:

- To establish people's perceptions of blood donation

- To identify opportunities for the use of ICT for blood donation

The System Objectives of this project were:

- To create a well-indexed record of blood donors to enable tracking of repeat blood donors
- To test the concept of using ICTs to increase blood donation rates through donor awareness and education

The research questions for this project included:

- Why are there few repeat blood donors?
- What strategies can be used to improve donor recruitment and participation?
- How can ICT be used to improve the donor recruitment and retention processes?
- How can ICT be used to motivate people to donate blood?

1.4 Justification of the Study

On 13th June 2014 the KNBTS Director Dr. Margaret Oduor announced that the country had a total 2,848 litres of donated blood countrywide which is equivalent to two days' stock. Kenya faces a chronic blood shortage with less than half the required units collected each year.

The donor age profile in Kenya according to KNBTS shows that majority of the donor are 16 - 20 years of age (57.7%) (KNBTS report, 2012). Focus Group Discussions (FDGs) conducted at two secondary schools in the KNBTS Nairobi region revealed that once the students are out of school they are no longer reminded to donate. Blood drives are organized regularly in secondary schools and KRC clubs within the schools conduct donor education and awareness sessions. 27.8% of all donors in Kenya are between the age of 21 and 25 which is a big drop from the number of donors in secondary schools. Based on this statistics, it makes sense to have a record of regular donors and at the same time explore the potential of the use of technology as a donor recruitment and retention strategy.

The manual blood and donor management systems in use by KNBTS have proven inadequate over the years. The use of a detailed blood inventory management system that keeps track of the usage of the different blood groups, prioritizes these groups based on their availability and that

alerts the relevant authorities before blood amounts reach a critical level would greatly improve the time it takes for a patient to receive blood and would allow for accurate record keeping necessary for accurate data analysis and reporting and efficient planning especially during emergencies.

1.5 Scope of the Study

Research was done within and around Nairobi region and a solution was created and tested using test donors to confirm that they received useful information in a timely manner. This solution fully automates data and information management at the blood center. Information received from donors during donor recruitment was used to contact and inform donors.

The solution can later on be scaled up and be customized to suit operational needs of its users at any blood center in the country.

Functionality areas of the solution include:

- Donor Management - This helps ensure availability of a constant supply of blood because it enables more efficient donor retention strategies. It includes donor registration and profiling (including full contact information and last and next expected date of donation, blood type etc.), donor recall and scheduling (via SMS)
- Bank/Inventory Management - This ensures timely access to important information especially on blood stock levels to enable timely decision making
- Reports - Some of the reports that the prototype system is able to generate include: stock movement/usage report, donor tracking report and blood request details report

2. LITERATURE REVIEW

2.1 Introduction

Timely access to safe blood is part of the WHO's global health agenda and global strategic priorities (WHO Regional Office for Africa, 2009). The lack of timely access to safe blood by patients and the big gap between demand and supply of blood are problems faced by many countries especially those in the developing world. For these reasons, organizations charged with the responsibility of running transfusion centers both in the developed and the developing world are turning to technology to explore the potential solutions it has to offer for these problems.

Information and Communication Technology (ICT) has had a big impact on health in countries that have already adopted it. This has been because of the constructive dialogue that has been occurring among health practitioners, patients and heads of the healthcare world both in the health ministries and the private sector. Technology for Health has revolutionized health records management, facilitated access to medical care via remotely telemedicine in developing countries and with the use of their mobile phone enables patients monitor their own vital signs and chronic conditions (Eric Topol, TedMed 2009).

ICT integration in health depends mainly on a country's reality, priorities, long–term budgetary prospects and commitment. In the Kenyan context, this would mainly depend on the structures put in place and the policies made by the government through the MoH. It would also depend on the uptake and adoption of the technology by the various stakeholders especially the medical practitioners and the patients that interact with the technology directly.

In many if not all developed countries, the National Blood Transfusion Service (NBTS) has an integrated blood and donor management system. Donor register is done on the organization's website or when the donor visits the blood collection centre after which the donor is contacted either via SMS or email. There are also many other online blood banks, donor databases and blood donor mobile applications set up by organizations independent of the NBTS. These organizations ease the processes of recruitment and mobilization of donors whenever there are urgent blood appeals and also keep donor blood donation records and test result details.

Below are screen shots of examples of these applications:

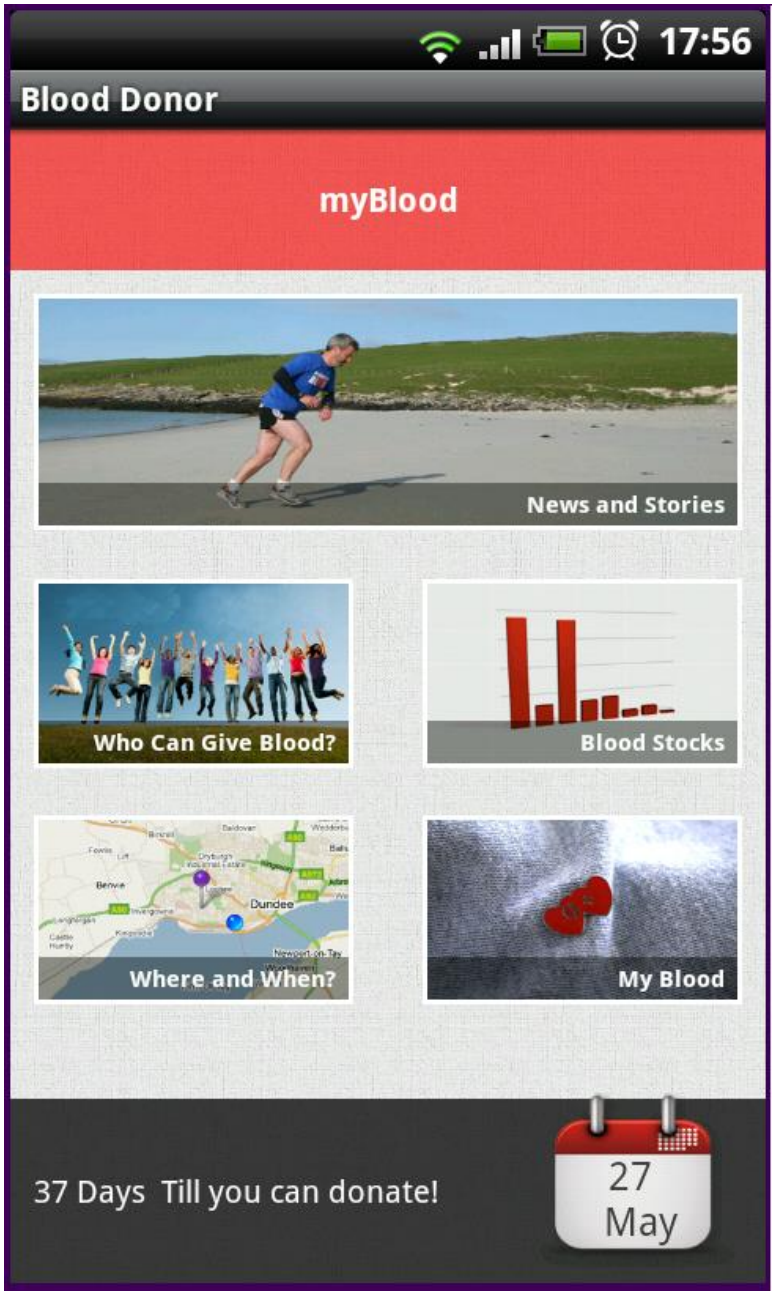

Figure 1: MyBlood Application by James McLaren Jamie Shek, Dundee University (2011)

MyBlood is an application developed for the Android mobile phones. It aims to encourage new and current blood donors to give blood regularly and make it easier to do so in the process.

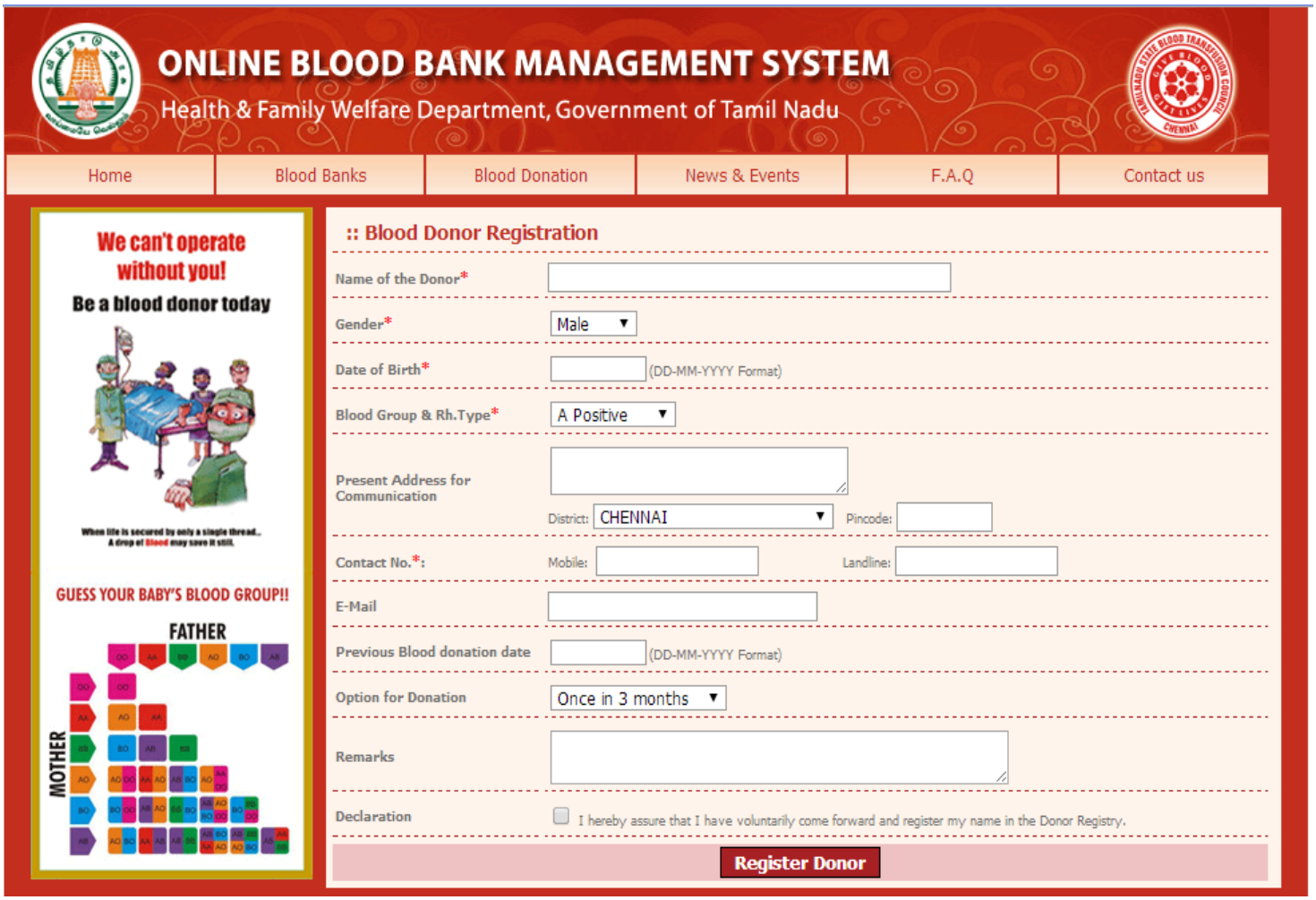

Figure 2: Online Blood Donor Registration Form (www.tngovbloodbank.in/)

This is the online donor registration form found on the Tamil Nadu National Blood Transfusion Service website. Donors enter their location and contact details and choose after how long they would like to donate so that they can be contacted when time comes.

2.2 Blood Products and Blood Usage

2.2.1 Blood Products

- **Blood Groups**

There are more than 30 major blood group systems but the most important blood groups when referring to blood donation, blood transfusion and life threatening conditions such as Hemolytic disease of the newborn (HDN) are the ABO blood group system and the RhD blood group system. Blood groups are determined by a protein (antigen) on the surface of the red cell. So, the ABO system has A and B antigens and the RhD system has the D antigen. A person's blood group is defined by their ABO group together with their RhD group. For instance, someone who is group A and RhD negative is known as A negative (A-). Approximately 83% of people have the D antigen and are RhD positive while the remaining 17% lack the D antigen and are therefore RhD negative (Dean, 2007).

The table below explains the compatibility and distribution of the blood groups. For both whole and Red Blood Cell (RBC) donations and transfusions, the RBC compatibility should be checked.

ABO Blood Group											
	Donor								Rh(D) Type	% of population with this group	Total
Recipient	O-	O+	A-	A+	B-	B+	AB-	AB+			
O-	✓	✗	✗	✗	✗	✗	✗	✗	Neg	7%	Group O 44%
O+	✓	✓	✗	✗	✗	✗	✗	✗	Pos	37%	
A-	✓	✗	✓	✗	✗	✗	✗	✗	Neg	7%	Group A 42%
A+	✓	✓	✓	✓	✗	✗	✗	✗	Pos	35%	
B-	✓	✗	✗	✗	✓	✗	✗	✗	Neg	2%	Group B 10%
B+	✓	✓	✗	✗	✓	✓	✗	✗	Pos	8%	
AB-	✓	✗	✓	✗	✓	✗	✓	✗	Neg	1%	Group AB 4%
AB+	✓	✓	✓	✓	✓	✓	✓	✓	Pos	3%	
								Total	Neg	17%	
									Pos	83%	

Table 1: Blood Group Compatibility and Group % Distribution in the UK (redcrossblood.org and blood.co.uk)

- **Universal donors and universal recipients**

Individuals with type O Rh D negative (O-) blood are often called universal donors (but can only receive from themselves), and those with type AB Rh D positive (AB+) blood are called universal recipients.

- **The rare groups**

Based on the above information, the rare blood groups are:
O- is 7% and can only receive from itself
A- is 7% and can only receive from O- (7%) and A- (7%)
B- is 2% and can only receive from O- (7%) and B- (2%)
AB- is 1% and can only receive from O- (7%), A- (7%), B- (2%) and AB- (1%)

- **Blood Products**

The most common blood products used for blood transfusion include: whole blood, RBCs, platelets, plasma and Cryoprecipitate (Repine, 2006). Blood products have different shelf lives which are dependent on several factors the most important one being storage, that is the type of blood bag used and the temperature of the storage area. For RBCs, the expiry date depends on the types of anticoagulants and additive solutions used. Once the blood bag seal is open, the blood product must be used within 24 hours (Rubin, 2011).

The blood product shelf lives are as shown below:

Whole blood – 35 to 42days
Red Blood Cells – 42 days
Platelets – 5 days
Plasma – 48 hours
Cryoprecipitate (frozen plasma) – up to 1 year

The KNBTS disposes whole blood 35 days after its collection date, unfortunately once blood is discarded and is out of stock it not replenished immediately. A blood bank system that takes into consideration the different factors that affect the availability of blood such as expiry dates of

blood products and the demand for the different blood groups especially the rare ones will effectively ensure that there are no shortages even during emergencies.

2.2.2 Blood Usage

The WHO estimates the minimum annual blood requirement need for any country to be 1% of the country's total population. Kenyan's population is 40 million people and therefore the blood requirement is 400,000 units of blood. Less than half of this number is collected (KNBTS Report, 2010). KNBTS as of 2013 managed to collect 170,000 units of blood which is 42.5% of the 400,000 units required by the country annually (KNBTS Report, 2013). In 2014 the KNBTS national director estimated the blood requirement need at 2,848 liters for every two days (Odour, 2014).

Once blood is collected, it is screened for infections. KNBTS tests blood for HIV, Syphilis Hepatitis B and Hepatitis C to ensure patients receive non-reactive blood (Basavaraju, Mwangi, et. al., 2010). The KNBTS discards blood that is found to be reactive and that has expired. The prevalence of HIV among blood donors is estimated 6.4% (Moore, Herrera, et. al., 2010). This together with Hepatitis and Syphilis positive blood is discarded. During emergencies the KNBTS collects more blood than its facilities can store and therefore most of the blood is discarded.

2.3 ICT for Blood and Donor Management

2.3.1 Zambia: Integrated Blood Donor Database Management System

In Zambia, blood safety is among the priority medical interventions that are expected to significantly contribute to the achievement of the Millennium Development Goals (MDGs). The Zambian blood donor management system relates especially to child and maternal health, the fight against the HIV/AIDS epidemic, TB and malaria (IICD, 2009). Since 1998, the country has made significant achievements towards the establishment of a comprehensive, nationally coordinated blood safety system, based on the WHO guidelines on the organisation and management of national blood safety programmes (WHO, 2014). The Zambia National Blood Transfusion Service (ZNBTS) was set up by the Zambian Ministry of Health (MoH) and is the institution mandated by the this ministry to coordinate and manage the national blood transfusion

programme. That is, it runs the country's blood safety system and is therefore responsible for the collection, screening, processing, storage and distribution of blood in the country.

The Integrated Blood Donor Database Management System in Zambia for with the support of IICD's Zambia Country Programme and Cordaid and started in July 2008. The project involved developing and implementing a computer based Blood Donor Tracking System. This system was developed for use by the staff of ZNBTS who were trained in basic ICT by the e-Brain Technical Support Group, and with the aim of reducing the risks of incorrectly identifying donors and blood units (IICD, 2009).

The three main objectives the ZNBTS project aimed at achieving include:

- To develop and maintain an appropriate integrated blood donor tracking database system for the efficient and effective recording and management of blood donor data and blood donor retention. The use of a blood donor tracking database system improves the quality of recording and management of information about blood donors which facilitates the effective tracking of repeat blood donors and the establishment of a reliable pool of regular repeat blood donors
- To improve the accuracy, efficiency and effectiveness of tracking information on blood donations, from "Vein to Vein" and ensure blood safety through accurate labeling and identification of blood units at every stage
- To ensure sustainability through capacity building, staff skills training and the integration of the project into the plan and operations of ZNBTS.

The project is still in progress and according to ZNBTS, more than 17,000 blood donors and patients in need of a blood transfusion benefit from the blood donor tracking system. This is because repeat donors can effectively be tracked and a reliable pool of regular repeat blood donors has been established. The system also ensures blood safety through accurate labeling and identification of blood units at every stage.

With the old paper based donor system all donors including the regular ones, had to fill out new registration forms every time they donated blood, because the old forms were not stored in an accessible way. The problem was that if a donor moved to another location, even if this was only to another village or city, and wanted to donate blood again they would then have to redo the

entire registration process. But with the integrated blood donor tracking system donors only have to register once with ZNBTS if they want to donate blood, even if they have moved from one province to another. This is because the donor database is accessible from every ZNBTS office. With this donor tracking system retention of reliable blood donors, from low risk population groups is easier.

The donor tracking system makes it easier to reach registered blood donors since ZNBTS has their contact details are in its donor database. Registered donors receive text messages reminding them that they can donate blood. A simplified version of the text message is:

"*Dear sir, you are kindly reminded that you are able to donate blood again*."

This text message comes from a fully automated system that recognizes when a donor is capable of donating blood again and therefore sends him or her the text message in advance (Hernández and Jessurun, 2009).

The blood donor database was developed using open source software called Kannel which also runs the SMS system. It is an adjustable program that is listed in The Free Software Directory; a project of The Free Software Foundation (FSF) and the United Nations Education, Scientific and Cultural Organization (UNESCO) (Mulenga - IICD, 2010).

2.3.2 Malawi: Blood Donor Management System

In 2003 the Government of the Republic of Malawi with funding from the European Development Fund (EDF) and the Commission of the European Communities (EC) and in accordance with WHO recommendations and guidelines, established an independent and autonomous Malawi Blood Transfusion Service (MBTS) with three Blood Transfusion Centres.

MBTS has an autonomous Board of Trustees (MBTS Trust) which has facilitated the setting up the Malawi blood donor programme and the formation of the Blood Donor Association of Malawi (BDAM) whose aim is to ensure blood donor education and recruitment is coordinated and no longer fragmented as it was before MBTS was established. BDAM works to bring together all the disparate blood donor interests under one body in order to improve and unite the national blood donation campaign and help diffuse any misconceived myths and

misunderstandings that had been prevalent in the past and led to low donor turn outs during blood donor recruitment (Emmanuel, 2006).

MBTS provided 66.7% of all the blood used by hospitals in Malawi in the year 2005 (Kongnyuy and Broek, 2007). The organization did not have the capacity to provide blood required by many of the district hospitals in the country.

MBTS aims to increase this and has therefore opted to use technology for donor recruitment and retention strategy. In 2005, the MBTS IT Department was tasked with the responsibility of overseeing the development of a Blood Donor Management System (BDMS) by a Malawian IT company. This system is an important component of the donor management and recall system as well as the laboratory 'look-back' system. The laboratory 'look-back' system tracks serological markers and statistical analysis.

The donor management system is operational and currently in use in the all the MBTS regional offices (Emmanuel, 2006). The regional IT officer is responsible for training secretarial staff, laboratory and nursing staff on data capture and retrieval using the systems. With the BDMS in place, MBTS now supplies all four central hospitals and 80% of district hospitals in the country.

2.3.3 Australia: National Blood Management System

The Australian Jurisdictional Blood Committee supported the development of the National Blood Supply Contingency Plan(NBSCP) which put in place a framework that enables the Australian National Blood Authority (NBA) respond rapidly to national blood supply threats. The implementation of the National Blood Management System (NBMS), a computerized blood management system that supports fresh blood collection, processing and distribution is part of this contingency plan. The system also includes a donor management and patient management applications. (NBA, 2011).

The NBMS regularly assesses the stock levels and anticipated requirements based on requests made by hospitals after which donors are contacted to donate blood. Since its inception in 2003 the NBMS has increased blood stock that is available to hospitals despite encountering down times the system has improved inventory management by NBA.

2.3.4 The Kenyan Situation

Text4 life

The Kenya National Blood Transfusion Service (KNBTS) is the institution mandated by the Kenyan Ministry of Health (MoH) to coordinate and manage the national blood transfusion programme. Interviews conducted at the KNBTS national office revealed that the institution has a manual Blood Bank Management System and that most of the processes including record keeping and inventory management are manual. KNBTS has intentions of eventually automating its processes and has recently started storing some data in excel format, but at the moment most of its data is in paper form.

In January 2013 KNBTS launched a project funded by the CDC Foundation and supported by partners including the Blood Link Foundation, Intellisoft Consulting and mHealth Kenya. The main aim of this project being to come up with a solution to avert low donor turn outs and encourage donor participation during blood drives. The project involves the creation and setting up of the text4life system, a platform through which KNBTS aims to ease the process of donor mobilization by sending text message notifications to potential donors on dates and venues of future blood donation drives in their county. Using this system, a potential donor registers online on the KNBTS website by entering their phone number, email address and county of residence.

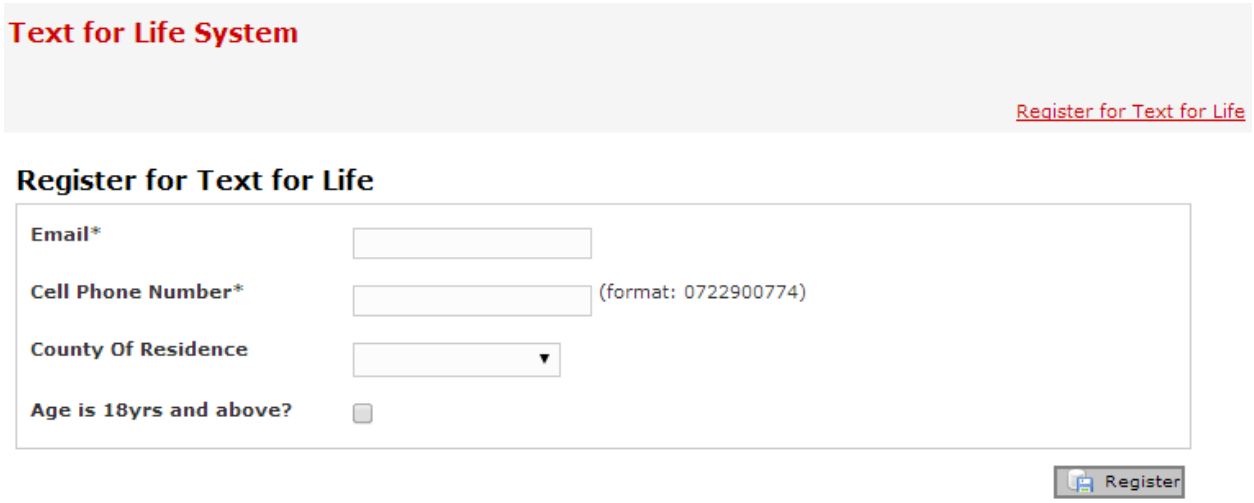

Figure 3: Online Registration Text4Life, KNBTS (nbtskenya.or.ke)

Once donors register online they can receive text messages on when and where KNBTS is holding donation drives and also the results of their blood screening test. So far 60,000 donors have been registered since the inception of text4life in August 2013, before this a pilot was conducted in March 2013 in Nairobi. Online registration of donors in Kisumu and Mombasa started in January 2014. The project is still on going and evaluation was scheduled for September 2014.

Some of the shortcomings of this system include: A donor must register by filling in a paper form before being allowed to donate blood, even when they have registered online. One of the reasons for this is that the online registration form collects only the contacts and county of residence of the donor, details like age, gender and blood group are not entered online. The main aim of coming up with the text4life system was to enable donor mobilization and not donor management.

A study conducted on the perception of blood donation reveals that not all donors who register for text4life receive text notifications on dates and venues of blood drives or the results of their blood screening test. Some of those who receive text messages from text4life stop the service. Using this system, a potential donor registers online on the KNBTS website by entering their phone number, email address and county of residence.

The KRC and several other organizations including Pledge 25 focus on mobilizing donors and creating donation awareness among the public on behalf of KNBTS. These organizations do not run blood banks and therefore do not collect or distribute blood. They also use social media and members of their clubs in schools and campuses across the country to create awareness. This shows that most of the blood collected by KNBTS is from the youth of between 16 and 25 years of age.

Wanadamu Initiative

In June 2014 Orange Kenya partnered with WANADAMU in creating an online blood donors database. WANADAMU is an initiative started in 2011 by Kuna Vijana and operates in Kenya & Ghana. The project is currently its initial stages and the online database is not yet in place.

The aim of creating an online donor database is to ensure that willing blood donors in Kenya can be contacted in the event their blood group is needed urgently by someone who requires a transfusion. Once an appeal is made, the WANADAMU database is filtered and sends mass messages to donors with the needed blood group. The organization plans to work together with hospitals to get information on those who require blood (Kunavijana, 2014).

The organization's goal is to bridge the gap between those in need of blood and donors. It currently does this by making appeals on social media and contacting people on its contacts list. To become part of WANADAMU a donor sends a text or email with your name and blood group to them. The organization has also set up a hotline for those in need of blood to call and make appeals (Kunavijana, 2014). http://www.wapidamu.org/

Life Buddy

Life Buddy is the winning innovation for the 2014 Microsoft Kenya Imagine Cup, a global student technology competition which centers on the use of imagination, creativity and technology to help solve some of the world's toughest problems. Life buddy is a mobile-based application created by the Africon team from the Jomo Kenyatta University of Agriculture and Technology (JKUAT) (Imagine Cup, 2014).

The mobile application that seeks to help blood recipients to easily connect with the blood donors of the same blood group as them. It allows anyone who needs blood urgently to quickly post a request on the app. The app then sends a notification to users of a compatible blood group and who are within a radius of 20 Kilometers. The willing donor then receives a notification providing them with the details of the hospital to donate blood to and the contacts of the recipient. Life Buddy saves lives by ensuring those who need blood receive it in the fastest possible time thus saving time (Kariuki - JKUAT, 2014).

2.4 The Perception of Blood Donation

With an ever increasing demand on blood supplies worldwide, there is an immense need to ensure the constant availability of blood and its products. The adequacy of blood depends on blood donation rates and numbers of blood donors. However, recruiting and retaining blood donors remain key challenges for blood agencies. In an attempt to address these problems,

researchers have identified a range of socio-demographic, organizational, physiological, and psychological factors that influence people's willingness to donate blood (Shah, Patil, et. al., 2011).

A survey was conducted in several secondary schools and tertiary institutions in Nairobi on the public perception of blood donation. The study aimed at capturing the knowledge, attitude, practice and information needs of both voluntary blood donors and those who do not donate blood.

Some reasons why people donate:

- Blood donation is seen as a noble cause and people feel good after they donate
- People want to feel needed and wanted and therefore they feel satisfied because they perceive blood donation as service to society.

Some of the reasons why people do not donate include:

- Lack of awareness on donation venues and dates and the lack of access to the blood donation centers
- Lack of donor education on the importance of donating regularly
- They do not donate because they are not informed on where blood goes and how it is used especially in public hospitals
- They who donate blood voluntarily do not get it when they need it
- They believe that hospitals sell the blood that they gave for free
- They do not donate is that they fear knowing their status
- They do not donate because they fear that do not have enough blood
- Another major reason is the fear of needles.

Some causes of discontinuity of blood donation among donors:

The lack of sustainable strategies to recruit and retain donors is one of the main challenges the KNBTS faces. The reasons why donors stop donating or do not return after they donate for the first time are diverse, and may correlate with demographic factors like age (Kasraian, 2005). A report published by KNBTS March 2012 indicated that majority of the donor in Kenya are

between 16 and 20 years of age that is 57.7% of all donors. The report also shows that donor between the age of 21 and 25 years make up 27.8% of all donors which is a decrease a big decrease from the previous age group. Focus group discussions held at two secondary schools

- They require feedback on their efforts which they do not receive
- They are not reminded to go donate or informed when and where blood drives take place
- They don't get blood when they need it
- They do not know where their blood goes especially when they donate in public hospitals
- They believe that when they donate their blood will be discarded and not used therefore there is no need to donate

Since we already know the reasons why people do not donate, how can we motivate and encourage them to donate? Can the use of technology help? In Kenya studies have been done on the need for computerized systems for management of blood banks (Nzoka and Ananda, 2014) but not on the perception of blood donation and the use of technology to manage blood donors.

Less than 2% of all the respondents of the study on the perception of blood donation have been contacted by the KNBTS and are aware of the text4life service. Most donors did not receive their screening test results despite being told that they will be contacted with the results. 67% of respondents, who had donated blood once, indicated that receiving immediate feedback on several aspects relating to their blood donation would motivate them. In addition, 79% of all the respondents would welcome educative information on blood donation via text message or email. 59% of the respondents knew their blood group even though the majority of both donors and non-donors did not know who is eligible to donate and how often one should donate.

The use of an automated donor management system would greatly benefit the KNBTS. Enabling the organization to contact and track donor is an achievable task mainly because:

There has been a drastic increase in mobile technology use over the recent years and it makes sense to make use of this technology to contact donors. Kenya has a mobile phone penetration rate of over 80% therefore almost every adult has access to a phone (ITU Report, 2013). Internet penetration rate is at an all-time high with 20% of Africa's population able to access the internet. This implies that more people would be able to access the KNBTS website today and register

online if they are unable to visit the KNBTS regional offices and register (ITU Report, 2014). Due to the increase in the use of the internet, there has also been an increase in access to tools that can be used to create awareness on blood donation such as social media.

2.5 Summary

Based on reviewed literature and the study on the perception of blood donation, lack of awareness and lack of donor education are the main reasons why people do not or stop donating blood. With increase in use of mobile technology a solution that utilizes this technology would increase the number recruited donors and help retain them. The use of a computerized BDMS would also help KNBTS reduce the number of blood units discarded due to expiry and reduce if not stop wastage of collected blood. A well designed computerized donor management system would ensure that only required blood groups are collected at a time, and that there is a constant supply of blood in the blood banks through regular collection from repeat donors.

KNBTS and other blood centers around the country currently lack a computerized BBMS and database of blood donors. Its manual systems are not effective and lack the capability to handle issues that prevent donors from donating blood. Communication from blood donation service to the donors should be enhanced and therefore the most suitable solution is an ICT based blood donor information needs driven system.

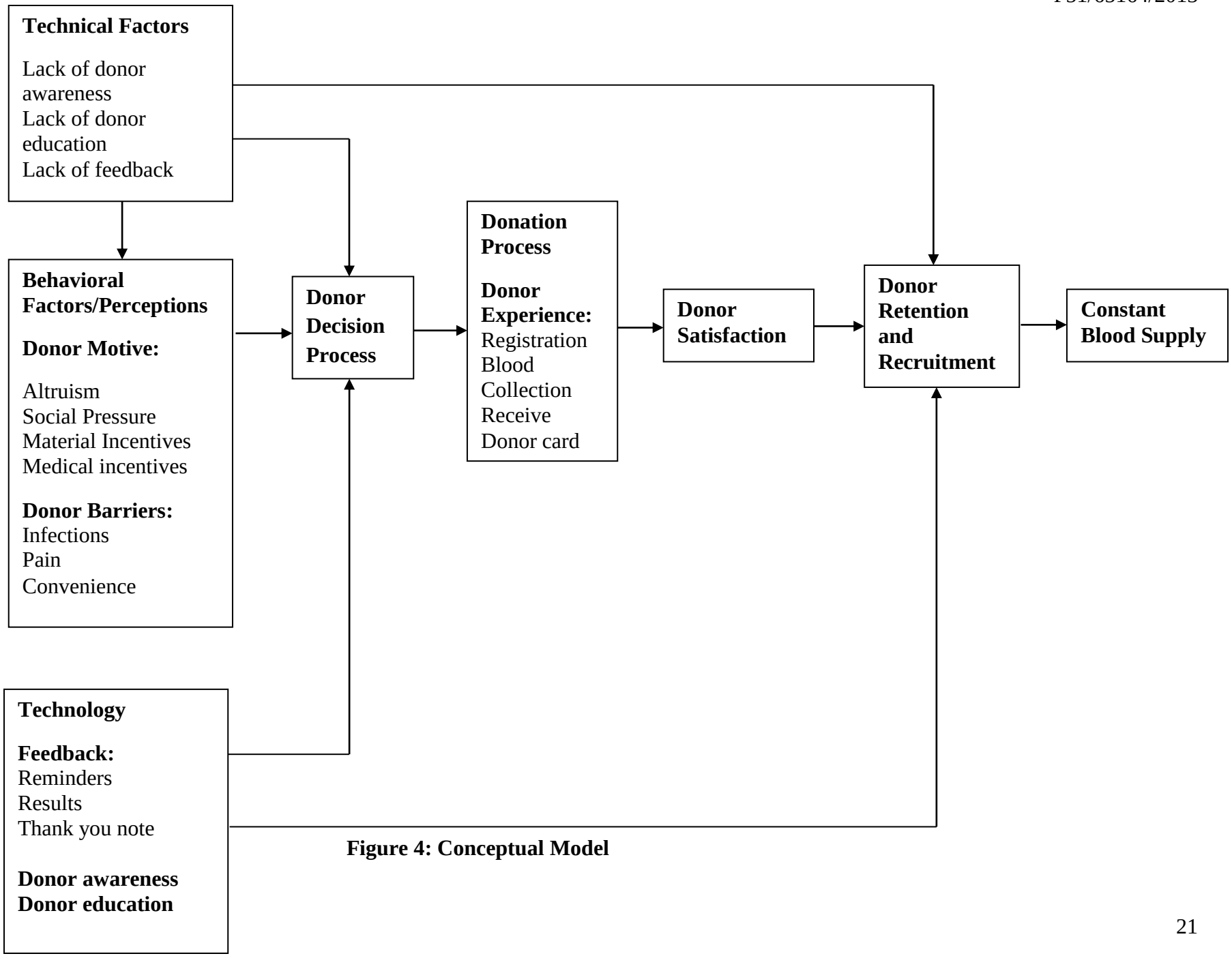

Figure 4: Conceptual Model

3. METHODOLOGY

3.1 Research Methodology

This research work had three components that comprise of:

- Information gathering on the perceptions around blood donation – this enabled us to identify the issues
- Design and development of a prototype
- Testing of the prototype – this enabled us test our concept around the use of ICT for blood donation

3.2 Information gathering

This research study is based on information gathered on the perception of blood donation and the use of technology for blood donation in Kenya and other in countries around the world. The use of technology in this case refers to the use of computerized systems to manage blood donors.

No similar studies have been done in Kenya, and therefore both exploratory and verification approaches will be used for this research with the aim of formulating the hypothesis that ICT can be used to improve blood donor participation in Kenya as it has in other countries. A pragmatic approach to research which involves a mix of the qualitative, quantitative and the participatory research methods will be used to verify the hypothesis that ICT can be used improve blood donor participation in Kenya.

A preliminary study, the perception of blood donation, was conducted to support the formulation of the research problem statement and research questions. The study applied a mix of both the qualitative and qualitative research methods and the research strategy used was the survey method for which a mix of data collection methods (Creswell, 2002) was utilized.

3.2.1 Population and Sampling

Population

The objective of this research was to come up with a solution that will ensure the increase the amounts of blood collected by the KNBTS Nairobi regional center. The preliminary study

targeted a population of students from secondary schools and tertiary institutions with in the Nairobi region. According to a 2012 report by the KNBTS, the donor age profile indicates that majority of the donors are 16 - 20 years of age (57.7%) followed by those 21 - 25 years old (27.8%). Two secondary schools and four tertiary institutions were selected for the study; two secondary schools – Alliance High School and Alliance Girls' High School, two public university - University of Nairobi (UoN) and Kenyatta University (KU), one private university – KCA University, one college – The Institute of Advanced Technology (IAT) The population is estimated to be a total of 50,000 students for all the institutions.

Sample Size

A sample is a subset of a population or simply the number of items to be selected from the population. The formula approaches to determining the sample size. The sample size for students was calculated using Yamane's formula (Yamane, 1967).

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = the sample size (50,000 students)
N = the population size
e = the level of precision $\pm 7\%$

$$n = {}^{50,000}/_{(1 + 50,000(0.07)^2)} = 204$$

Sample size for preliminary study is 204 students

3.2.2 Data Acquisition and Collection

A major part of understanding the existing blood and donor management strategies used by KNBTS involved gathering data in order to be able clearly define the existing problem and decide on the most suitable solution for this problem. The following data acquisition and collection methods were used for the collection of data for the preliminary study conducted on the perception of blood donation. Some methods were also used during prototype testing.

Interviews

Two different interviews have already been conducted:

- Interviews at the KNBTS national office to understand what structures and systems the organization currently has in place, how they work, how effective they have been in the blood collection and distribution processes (these are the successes and failures of the current systems) and what future plans KNBTS has.
- The Kenyan population, that is, the donors, those who have never donated blood and those who have been recipients of blood. What has been their experience and what are their expectations and their thoughts and views on the use of technology to improve the blood donation process.

Face to face interviews were conducted in both cases with individuals who represented the two groups. These interviews were used to establish what problems KNBTS and donors are currently facing.

Immersion

Immersion involves becoming a donor in order to fully understand the donor's experience and the whole process of blood donation. That is donor registration, physical checkup (both done to verify eligibility of becoming a donor), blood collection and receiving blood screening results. Receiving feedback from the donation officials is a key part of the donation process. For this research an immersion was done which involved attending a blood drive held at the Kencom bus stop in Nairobi.

Observation

During the immersion process, observations were done on the donation process and on donor interaction with donation officials. This involved carefully watching and listening to the donors and donation officials during the donation process.

Questionnaires

For the preliminary study, closed and open ended questionnaire questions were used to determine people's perception of blood donation. The study captured the knowledge, attitude and practice of both voluntary blood donors and those who do not donate blood.

For the prototype testing stage of this project, questionnaires were used in a survey on the use of an ICT based blood donor information needs driven system to improve blood donor participation with the aim of finding out if donor information needs are met through the use of the developed prototype solution.

Focus Group Discussions

Focus groups are small group discussions, addressing a specific topic, in this case the topic being blood donation. FDGs were used to compliment the questionnaire in the perception of blood donation study. The primary reason for using FDGs was to gather qualitative information that is beyond the scope of quantitative information gathered using the questionnaires.
The FDGs were done in the two secondary schools because 57.7% of donors are between the 16 and 20 years of age and therefore more qualitative information on the blood donation could be collected from this group. The discussions focused on the use of technology to improve the blood donation process and therefore improve donor participation.

Document Review

Study and review of material from past studies and projects done in other countries on ICT for blood donation is of importance since similar studies are yet to be done in Kenya. This method was used to determine the benefits and challenges other countries have faced and how different their blood donation programmes are since the introduction of Blood and Donor Management Systems in those countries. Data collected using this method was used to forecast what benefits Kenya could gain and what challenges it could face with the introduction of these systems.

This involved analyzing existing information found on published literature and blood donation websites. The data collected was mainly on the different blood groups, donation requirements and procedures, and the existing Blood Bank Management Systems and Blood Donor Management Systems.

3.2.3 Data Analysis and Interpretation

The data collected for both the preliminary and the prototype testing was both quantitative and qualitative and a statistical analysis using Statistical Package for Social Sciences (SPSS) was performed. Results of the prestudy were analyzed and lead to the formulation of the research objectives and questions. For the qualitative analysis, the text data obtained through the interviews, questionnaires, observations and documents reviewed was coded and analyzed for themes to enable analysis using SPSS. Data that was collected once the prototype system is in place was also analyzed using SPSS.

3.2.4 Ethical Considerations

Before conducting the study on the perception of blood donation, the respondents were informed of what the research project was about, its research goals and objectives and they gave their consent before filling in the questionnaires, answering interview questions and taking part in group discussions. All respondents were guaranteed confidentiality since they did not identify themselves using their names on the questionnaires.

Data collected using the Donor Management System was only shared with the donors when they receive their screening results and other educative SMS messages. Using this system, any blood donation agency is able to protect the integrity of donor data and preserve donor privacy by restricting access to donor data to authorized KNBTS personnel.

3.3 Summary of Methodology used

Objective	Methodology
Research Objectives	
To understand people's perceptions of blood donation and draw out donor information needs that can be used to improve donor participation	Survey (Interviews, Questionnaires, Focus Group Discussions, Immersion)
To identify opportunities for the use of ICTs to improve blood donation rates in the country	Survey (Interviews, Questionnaires, Focus Group Discussions, Immersion, Empathy), Document Review
System Objectives	
To create and maintain a well-indexed record of blood donors to enable tracking of repeat blood donors	Rapid Application Development methods to come up with a Donor Management System prototype
To test the concept of using ICTs to increase blood donation rates through awareness, education	Use of SMS technologies to create awareness and provide education Questionnaire to test if the prototype meets blood donor information needs

Table 2: Objectives and Methodology

4. ANALYSIS AND DESIGN

4.1 Preliminary Study

4.1.1 Results and Findings

A sample was randomly selected and a total of 224 respondents took part in the survey. It consisted of 118 men and 106 women from secondary schools, colleges, universities, the streets of Nairobi and its environs.

Variable	Attribute	Total Respondents	% of Respondents
Age	16-20	72	32.1
	21-25	75	33.5
	26-30	41	18.3
	31-35	16	7.1
	36-40	16	7.1
	41-45	1	0.5
	46-50	2	0.9
	51-55	1	0.5
	56-65	0	0
Gender	Male	118	52.7
	Female	106	47.3
Level of Education	Secondary	43	19.2
	College	32	14.3
	Bachelor's	107	47.8
	Master's	40	17.9
	Doctoral	1	0.5
Marital Status	Single	187	83.5
	Married	33	14.7
	Divorced/Separated	2	0.9

Table 3: Demographic characteristics of respondents

63.8% of all respondents had never donated blood and only a paltry 4.9% of the donors donated regularly. In this case, the regular donors are those that donate annually and between 1 to 3 times a year.

	Donors	Non-Donors
Male	49	69
Female	32	74
Total	81	143
%	36.2	63.8

Table 4: Donor and Non-Donor Representation

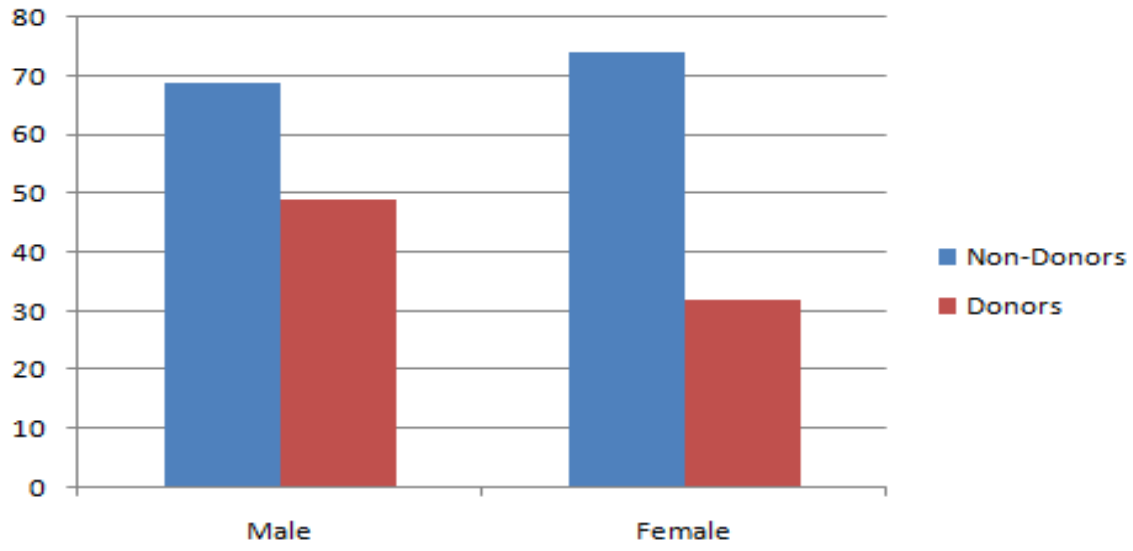

Figure 5: Donor and Non-Donor Representation

How often do you donate blood?	No. of Donors	%
I donated once only	45	55.6
Annually	5	6.2
1-3 times a year	6	7.4
I donate once in a while	24	29.6

Table 5: How often do the donors donate blood?

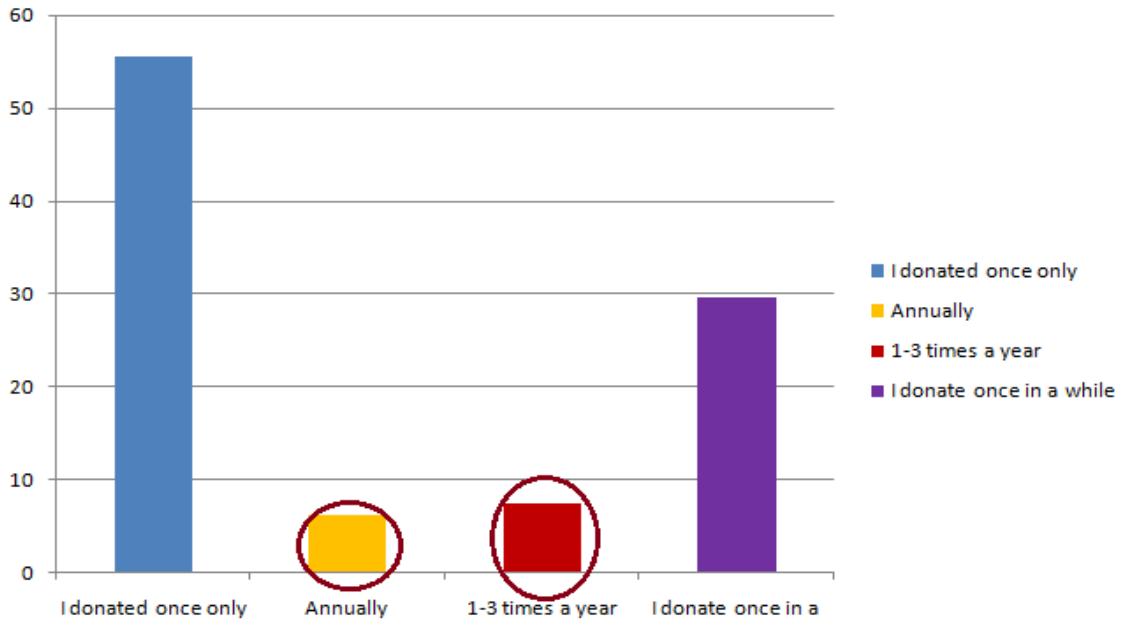

Figure 6: How often do the donors donate blood?

The study aimed at finding out what knowledge both donors and non donors have on donation. 3.1% of the respondents knew how often one should donate while 71% of the remaining respondents were either not sure or did not know. Only 7.6% were fully aware of who is eligible for donation.

Who should donate?	No. of Respondents	%
16-25 years, 50Kgs<, healthy, willing	17	7.6
Not sure	74	33
Do not know	92	41.3

Table 6: Knowledge on who is eligible for donation

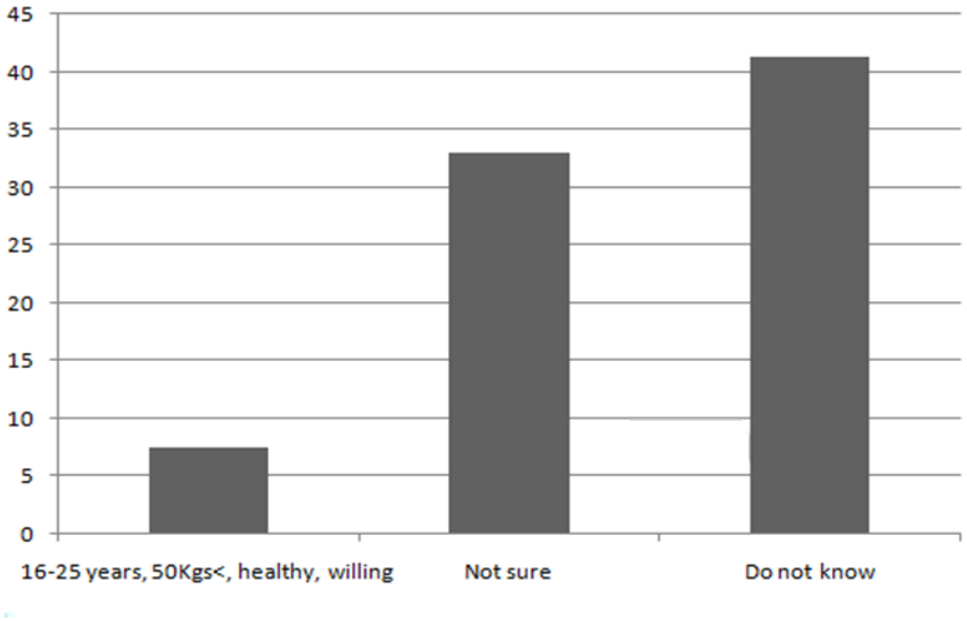

Figure 7: Knowledge on who is eligible for donation

How often should one donate blood?	No. of Respondents	%
Three months for male, four months for female	7	3.1
Not sure	67	29.5
Do not know	93	41.5

Table 7: Knowledge on how often an individual can donate

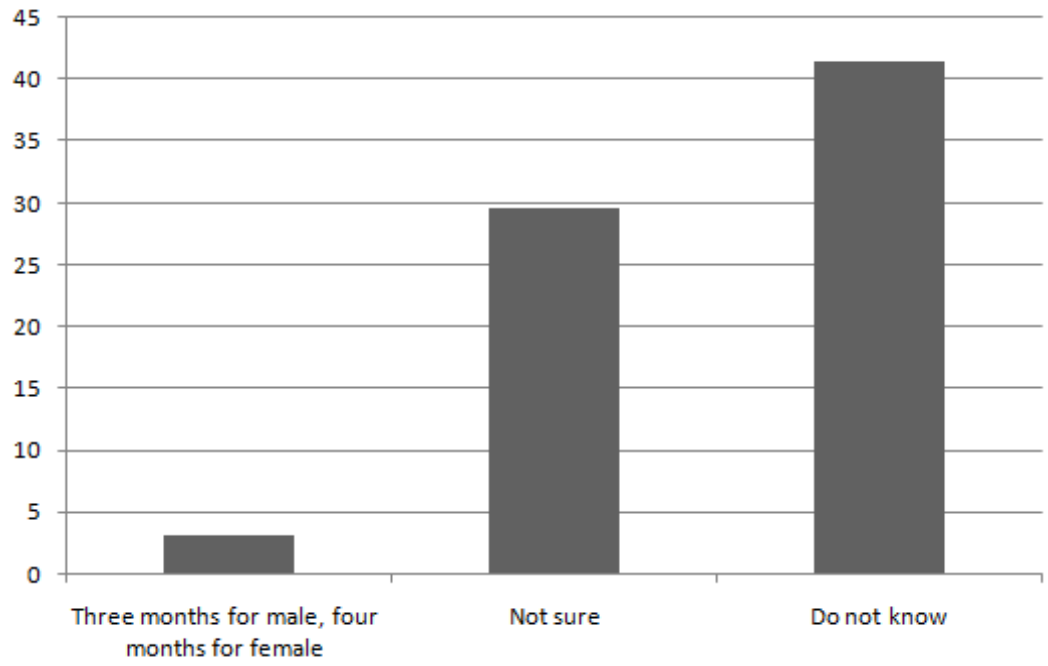

Figure 8: Knowledge on how often an individual can donate

48.1% and 32.1% of donors did not receive their screening results and their donor cards respectively and were also unaware of where and when to collect them. Very few donors have been contacted by either KNBTS or the health facility they donated at. Of the 81 donors only 19 had been contacted (11 via phone call, 6 via text message, 2 did not specify how they were contacted) to either collect their screening results, collect their donor cards or as a donation appeal. No donor was contacted through email. Of the 19 who were contacted, 9 were replacement donors and were therefore not contacted by KNBTS, but by the health facility where they donated.

Were you contacted by the blood center / donation official?	No. of Donors	% of donors
Yes	19	23.5
No	55	67.9

Table 8: Donors contacted after donation

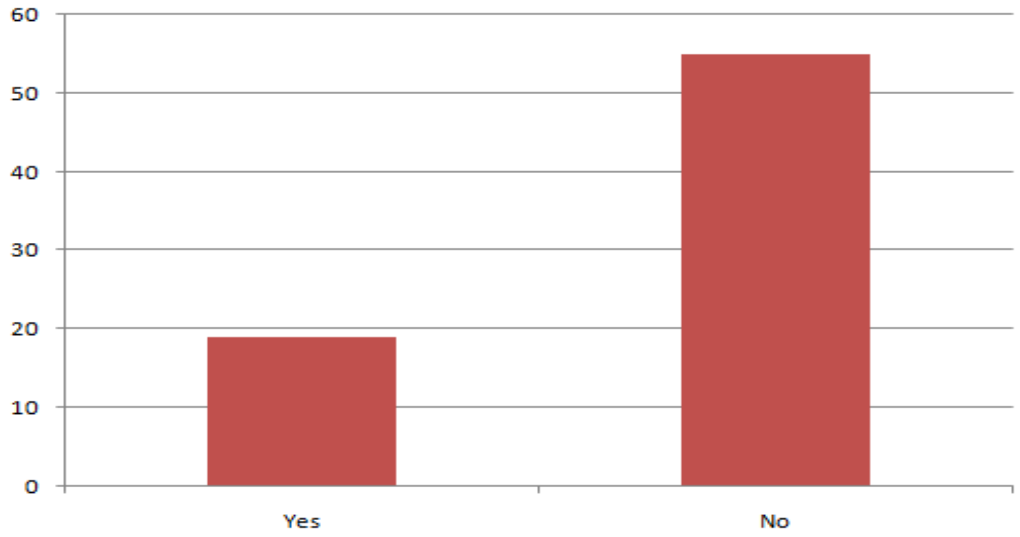

Figure 9: Donors contacted after donation

Method used to contact donor	No. of contacted donors	% of contacted donors	% of donors
Phone call	11	57.9	13.6
Text message	6	32.6	7.4
Email	0	0	0

Table 9: Method used to contact donor

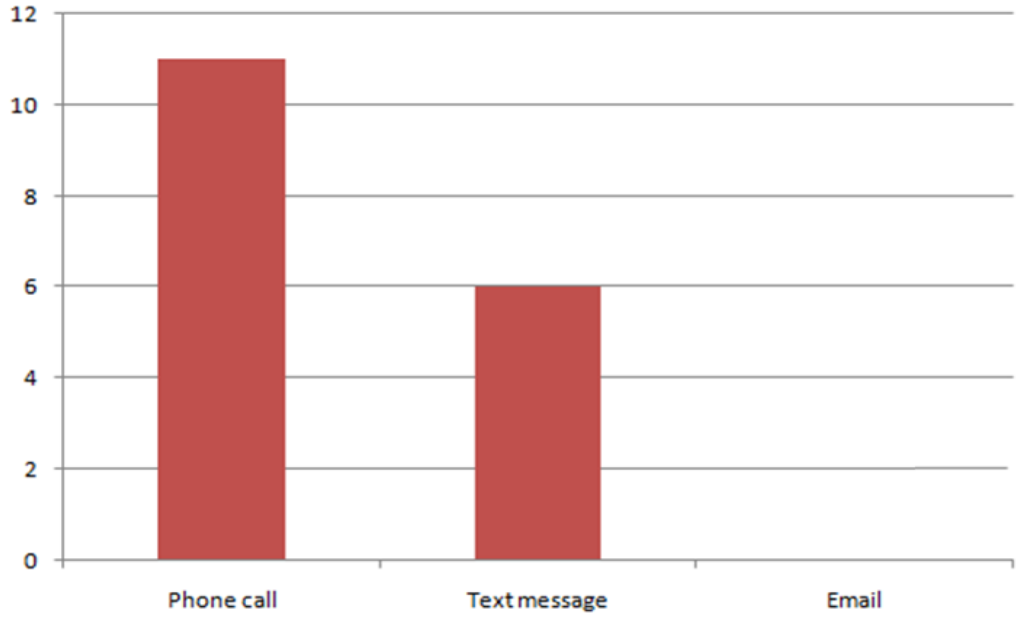

Figure 10: Method used to contact donor

Another objective of this study was to find out what feedback people would like to receive after donation. 31.7% and 32.7% of donors would like to receive feedback on the blood group and HIV status respectively. 48% of donors did not receive their screening results while 32% said they did not receive their donor cards after donation. This is because they were unaware of where to collect them.

Feedback donors would like to receive	No. of Donors	% of donors
Importance of blood donation	1	1
Future Donation Dates and Venues	7	6.9
Appeals for my blood type	5	5
How to receive donor card	3	3
Blood Group Results	32	31.7
HIV Status and other diseases	33	32.7
Was my blood viable and did it blood save a life	9	8.9
How was my blood used or is it at the blood bank	6	5.9
Thank you note for donating	3	3
Can I receive blood when I need it at little or no cost?	1	1
I would not like to receive feedback	1	1

Table 10: Feedback donors would like to receive

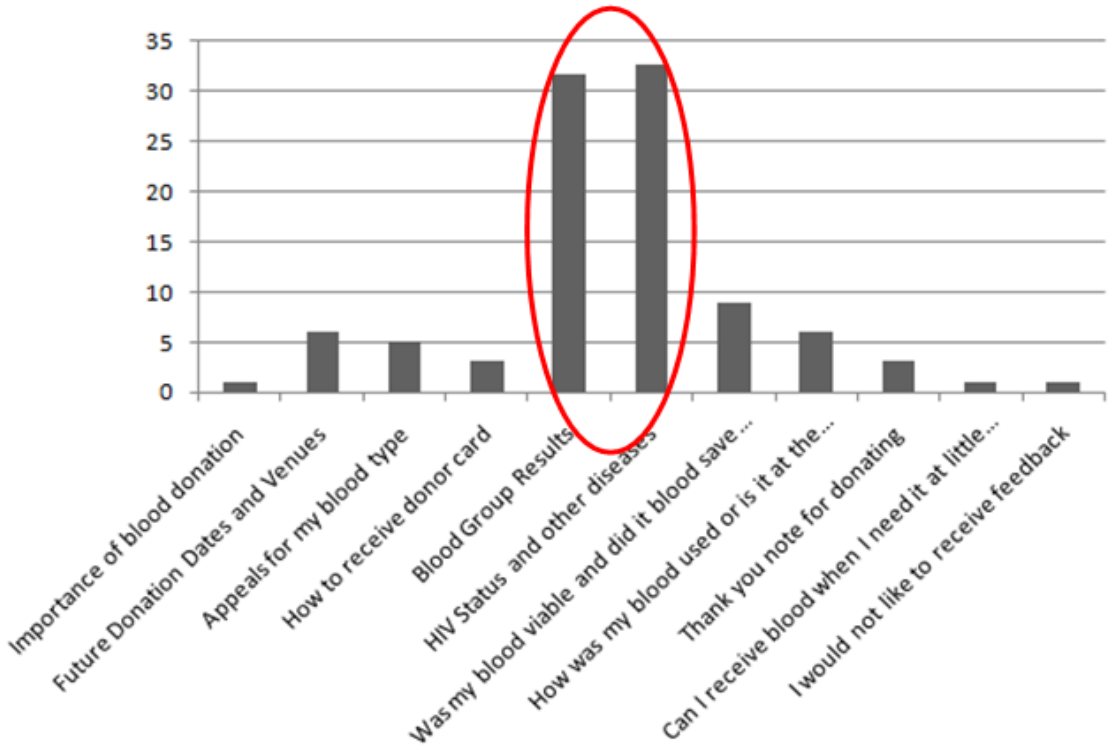

Figure 11: Feedback donors would like to receive

When asked if they would like to be contacted by the blood center, 71.4 % of all respondents indicated that they would like to be contacted via SMS and emails with useful information on blood donation dates and venues While 79% would welcome educative information on several aspects relating to blood donation via text message or email.

Would you like to receive information from the blood center via text or email?	**No. of Respondents**	**% of Respondents**
receive Educative Information via text or email	177	79
receive Venue and Dates Information via text or email	160	71.4

Table 11: Receive information from the blood center via text or email

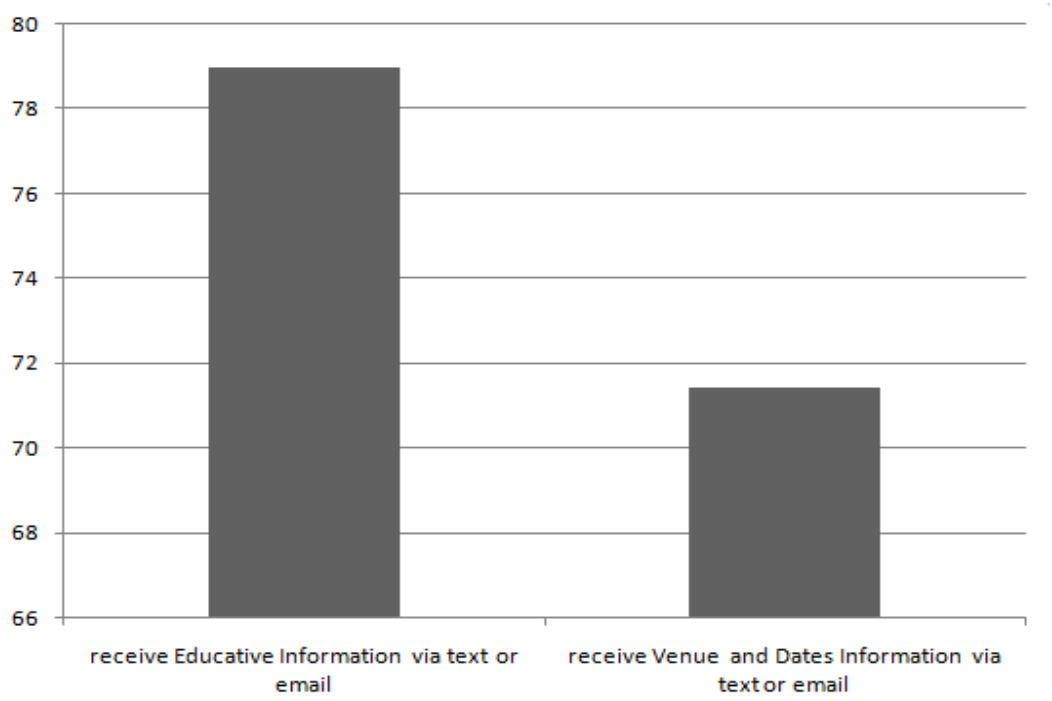

Figure 12: Receive information from the blood center via text or email

157 (70.1%) of the 224 respondents suggested that increased awareness on donation date and venues and increased donor education would improve donor retention and therefore increase donor participation.

Suggestions by donors on how to improve donor participation and encourage regular donation	No. of Respondents	% of Respondents
Increase Awareness and donor education	157	70.1
Increase the frequency of drives and the number of accessible donation sites/better facilities/better storage to avoid wastage	26	11.6
Use of Social media/text/email/mass media	22	9.8
Reward Donors and incentives for their efforts (better food, tickets, points, money)	18	8
Timely issuance of donor cards and others (information on how blood was used)	41	18.3

Table 12: Suggestions by donors on how to improve donor participation

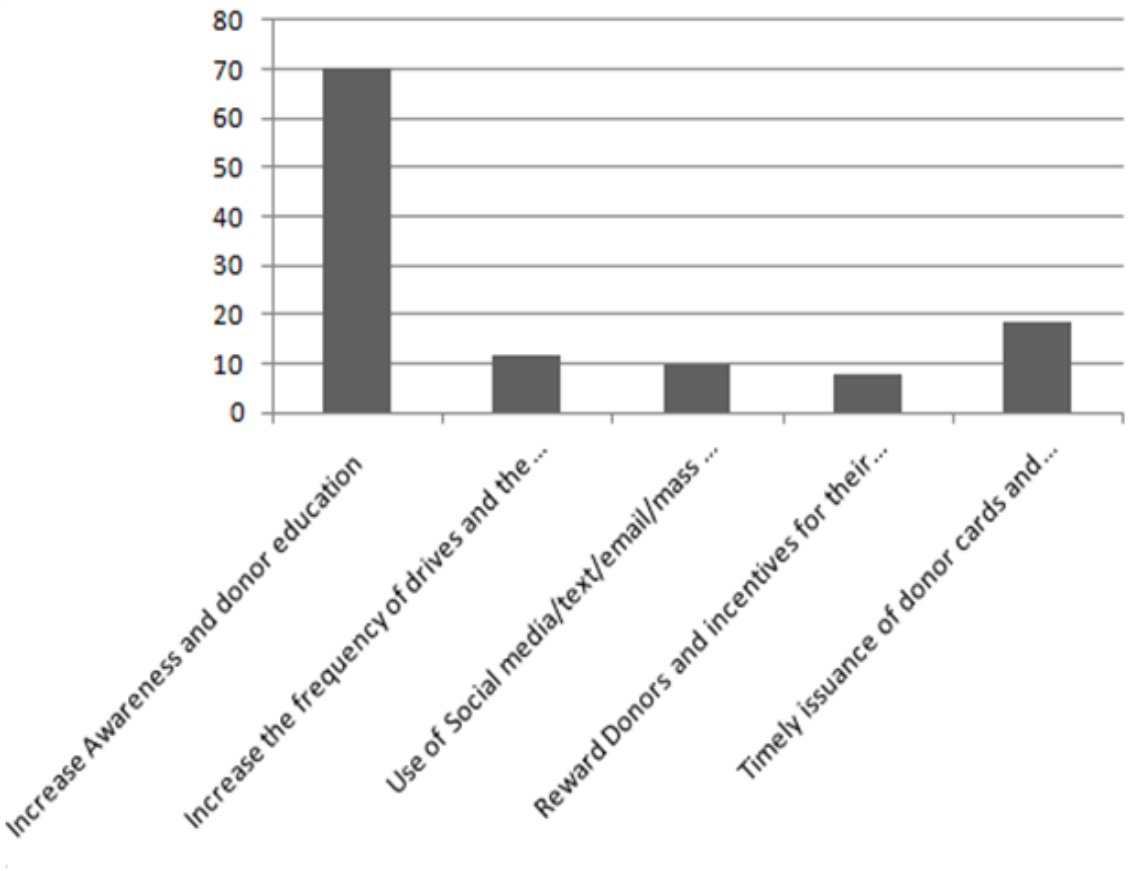

Figure 13: Suggestions by donors on how to improve donor participation

As part of the study, the current SMS based system used by the KNBTS was tested by a donor. Despite having registered for the KNBTS text for life service for over two months, the donor was not informed of ongoing donation drives within their county of residence. Once the donor had

donated, KNBTS sent a text message 40 days later thanking the donor and informing them of their donor number. Another text message was sent two and a half months later informing the donor that the blood has been used to save a life. The donor's donation date on the text message was also wrong. The information donors receive determines their self-efficacy levels which determines their likelihood of donating blood (Giles et al., 2004).

4.1.2 Discussion

- Most people do not donate blood
- Of those that donate very few donate on a regular basis
- Many of are unaware of donation drives and venues of convenience
- We noted weak direct donor and KNBTS communication
  - Few of our donor respondents had been contacted by KNBTS
  - Very few people are aware of the existence of the system despite it being in operation for over one year
  - Delays in relaying information to donors was noted with the text for life SMS system
- 79% of the respondents of this study welcome the use of technologies which are already available and in use in their day to day lives, i.e. SMS, email and Social Media
- This brings out gaps that can be filled using technology.

Issue/Aspect	**Gap**	**Design Implementation**
Little or no communication during donation process	Donor Education	Opportunity to use ICT (SMS/ Email)
Little or no knowledge on donor eligibility and how often they should donate	Donor Education	Opportunity to use ICT (SMS/ Email/ Social Media)
Little or no knowledge on donation dates and venues	Donor Awareness	Opportunity to use ICT (SMS/ Email / Social Media)
Little or no knowledge of when and where to collect donor cards and results	Donor Awareness	Opportunity to use ICT (SMS/ Email/ Social Media)
Fears, misconceptions, believes on blood donation	Donor Education	Opportunity to use ICT (SMS/ Email / Social Media)
No knowledge on the existence donor recruitment technologies (text4life)	Donor Awareness	Opportunity to use ICT (Social Media/ Media (TV/ Radio) / posters/ brochures)

Table 13: The use of ICT for blood donation

4.2 System Design

4.2.1 Existing System

KNBTS and most facilities with blood banks in the country manage their blood bank manually while others use a Blood Bank Management System. Majority of the times the BBMS does not keep records of blood donors and does not clearly show blood usage especially of the different blood groups. The blood bank system's process flow is as follows:

Donation → Screening → Storage → Dispensing

Limitations of using the Manual system:

- Retrieval of data is time consuming
- It is error prone and therefore has a lower accuracy levels
- It consumes a lot of manpower
- Its lack of data security
- Reports take time to produce

Limitations of the existing automated BBMS:

- Concentrates on collection, screening and storage of blood and not stock management and therefore is an unreliably way of keeping track of stock usage
- Lack of donor details therefore donors cannot be contacted during emergencies or reminded to go for donations
- Cannot generate blood usage reports and donor reports necessary for decision making

4.2.2 Prototype System

One of the goals of this research project was to study and analyze the effectiveness of existing Blood and Donor Management Systems, another objective was to enhance the existing system in order to ensure timely availability and adequacy of blood. For the development of the prototype, the preferred methodology is the Rapid Application Development (RAD).

Rapid Application Development

RAD is a development lifecycle designed to give much faster development and higher-quality results than those achieved with the traditional software development lifecycle. Fundamentals or this methodology are:

- Gathering requirements using workshops or focus groups
- Prototyping and early, reiterative user testing of designs
- The re-use of software components

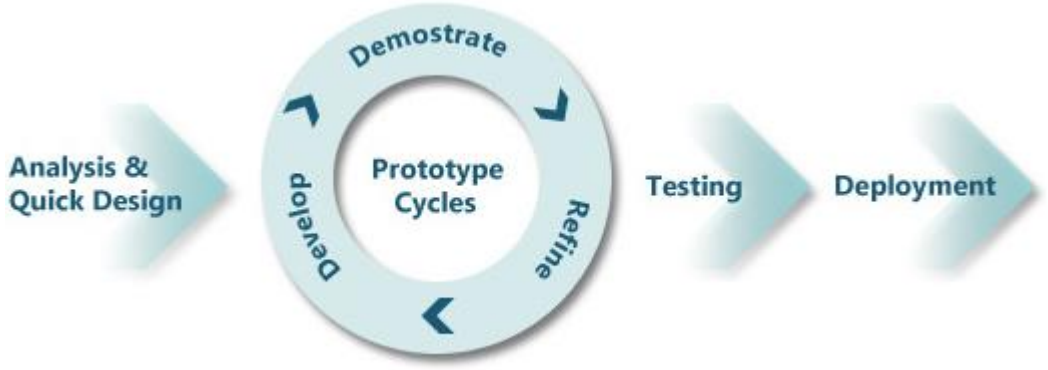

Figure 14 : Rapid Application Development Model (source: ramsoft.com.au)

Stages of Rapid Application Development

- Analysis and quick design: This involves requirements planning and prototype design
- Prototype Cycles: This stage is iterative and is where actual building of the software system takes place. A prototype is developed and demonstrated to the user after which it refined
- Testing and Deployment: Is where by the complete prototype is tested and is ready for use.

Prototype Description

The manual KNBTS systems do not keep records of blood donors and do not clearly show blood usage especially of the different blood groups. The blood bank system's process flow is as follows: Donation → Screening → Storage → Dispensing.

The developed solution extends the functionality of the existing BBMS and allows for more flexible, timely and accurate data and information management. The creation of this solution involved scaling up the exiting BBMS to not only concentrate on collection, screening and

storage of blood but to also enable registration of donors, monitoring blood usage and especially the blood types that are always in short supply but on high demand. The system enables:

- Donor Management – Donor registration, profiling, recall and scheduling via SMS
- Blood Stock/Inventory Management – Monitoring different blood group stock usage. Storing, retrieving and managing blood details electronically to help shorten response time and increase blood bank productivity
- Reporting –fast generation of all required reports to facilitate faster decision making and planning which is key especially during emergencies.
- Higher levels of data security compared to the manual system and ensure donor and patient confidentiality and privacy.

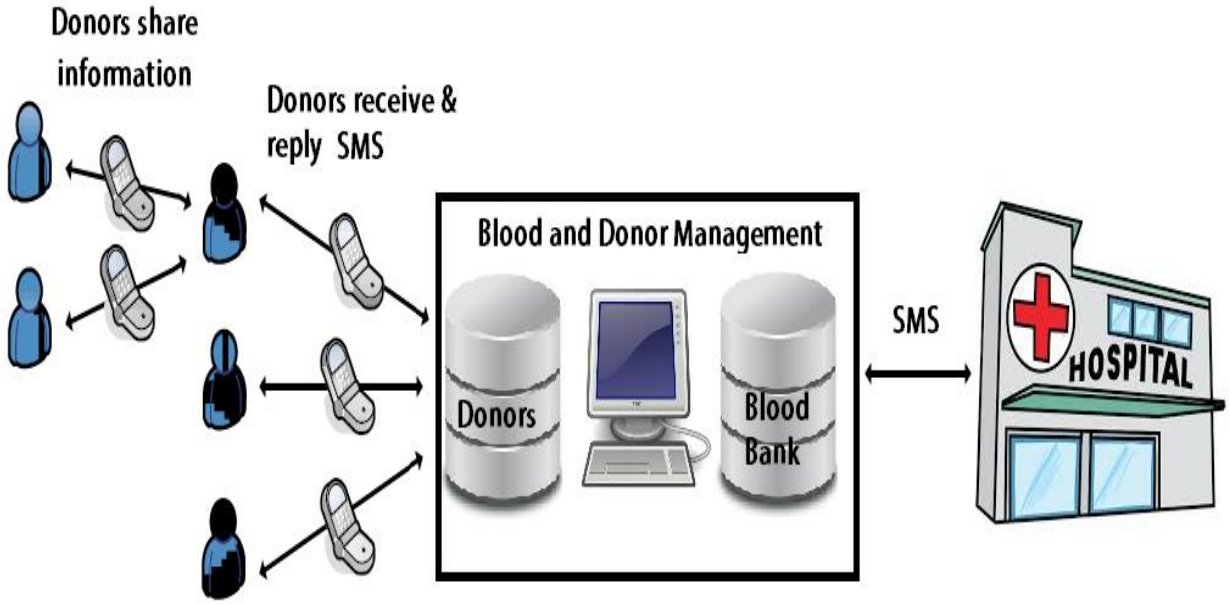

Figure 15 : Prototype overview

System Overview

This is a Blood Bank Management System designed to store, process, retrieve and analyze information the inventory management aspects of running a blood bank with focus on the rare blood groups which are always in short supply. It also fully automates management of information received from donors during donor recruitment.

- Donor recruitment and registration

This has to do with donor profiling and involves filling in a form with the donor's name, age, full contacts, blood group (if they know). The donor's age should be between 16 and 65 yrs old.
Donors receive an SMS message confirming their registration immediately after they are registered to the donor database.

- Blood Collection / donation

Once a donor is registered they can donate or wait for the required amount of time before they are allowed to donate. Male donors should donate every 3 months, while female donors should donate every 4 months. The donor should be at least 50kgs.
Donation can either be in-house, that is, within the facility (most regular donors fall under this category) or through mobile donation drives. In Kenya there are two types of donors: those who voluntary donate blood (mostly during mobile donation drives) and family/replacement done at the facility to replenish the hospital's stock.
The system sends a thank you message via SMS to donors every time they donate. This is to motivate them to come back.

- Screening for infection and blood Group

This involves testing the collected blood for infections during blood processing. If the blood is infected with Hepatitis B, Hepatitis C, Syphilis or HIV, it is rejected and discarded. The uninfected blood is banked. During screening, the blood groups are also determined. The ABO blood group and the RhD blood group system are commonly used. The groups are O, A, B and AB which can either be RhD negative or positive.
Once the results are ready, the donor is immediately informed of where and when to collect them.

- Blood storage and stock management

This shows usage for all the groups, that is, the received and available blood in the bank, the expired, infected, discarded and issued amounts from which a status report can be drawn.
Usage is monitored for every group and once volumes are at critical levels, donors are contacted to donate more blood.
Blood shelf life is also monitored. Blood shelf life depends on storage and the components of blood required (whole blood, Red Blood Cells (RBC), plasma).

- Donor recall and scheduling

This involves the use of SMS to inform the donors that they should donate. Ideally this should be done before the volumes reach critical levels.

Donor recall depends on the last date of donation and the volumes in the bank. Once the critical volume is reached there is a warning that levels are low and a trigger that activates contacting the donors via SMS.

Not all donors should be contacted, only those of the blood group that needs replenishing. This is to avoid wastage.

- Blood request and issue

A hospital can be registered to the blood bank and once it makes a request, a check is done to determine availability of the type requested for. If levels are critical donors are contacted, if not blood is issued. The blood bank is updated once the issuing is done.

Hospitals can also be contacted via SMS to make sure they have up to date information on the available blood groups.

- Reports

This includes donation and donor turn out reports.

System Design

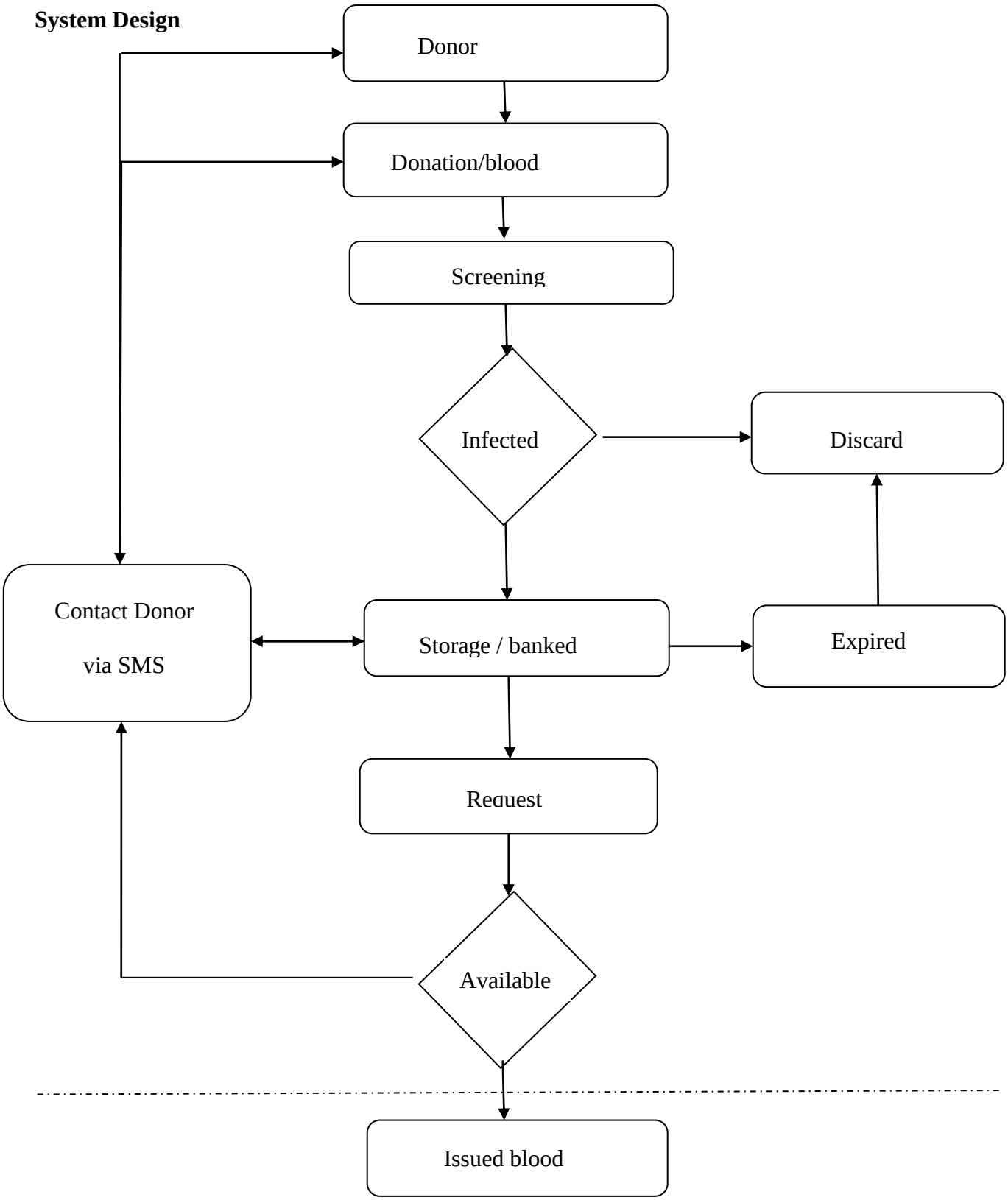

Figure 16: Data flow Diagram

The DFD shows the process flow from when the donor is registered to when the blood is requested for and issued to the patient in need.

Implementation

Development of the prototype involved closely studying the current systems and understanding how they function and what standards they follow.

Implementation tools include:

- The MVC Framework and MySQL to come up with a BBMS that allows:
  - registration and management of donors
  - a fully functional inventory management system
  - A friendly way to make requests and to issuer blood
- The use of SMS (twilio API) as a means to reach and remind registered donors of their next donation date

  This ensures:
  - timely access to blood of the required type
  - bridges the gap between demand and supply

5. RESULTS AND DISCUSSION

A survey on the use of an ICT based blood donor information needs driven system to improve blood donor participation was conducted. 20 people were registered as blood donors on this prototype system after which they filled in questionnaires to determine if their donor information needs are met through the use of this prototype system. The results below compare the current systems used by KNBTS and the prototype system. This is to show the gaps that have been filled by the prototype system.

From the preliminary study that was conducted on the perception of blood donation, only 19 of the 224 respondents (9%) were contacted by the donation center or hospital. 9 of the 19 were family replacement donors. With the prototype all respondents were contacted once they had been registered.

All of the 20 respondents indicated that they received the following messages via SMS:

- Registration confirmation
- Thank you message for donating blood
- When and where to collect their blood screening results
- Educative information on blood donation
- Venue and date for the next blood donation

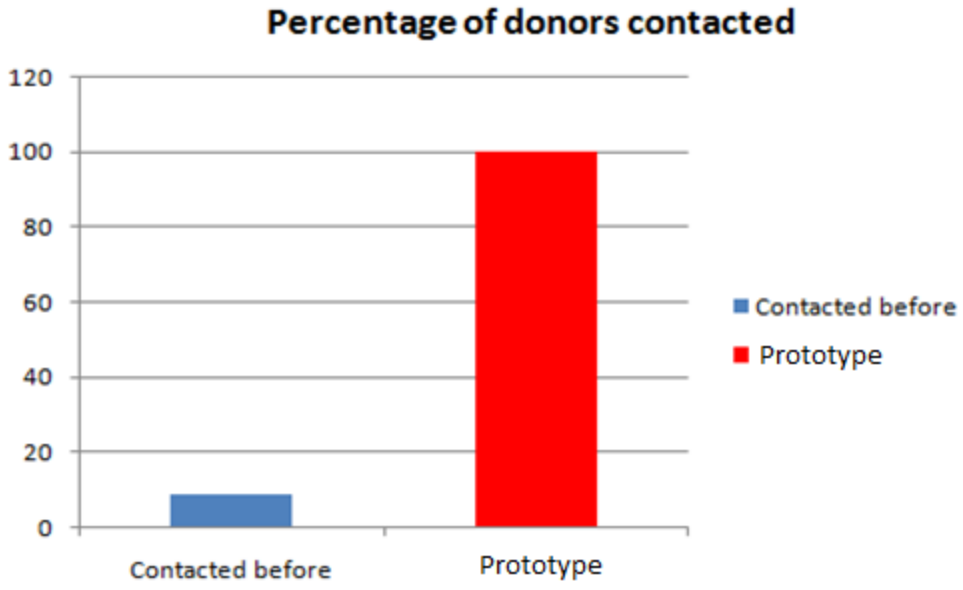

Figure 17: Percentage of contacted donors

With the Text for life system, there are significant delays in relaying information to donors and inaccuracy in the information sent. A donor registered on the 20th of June 2014 received a registration confirmation SMS on the 21st of July 2014, this is a month after registration and blood donation (see Figure 18). There are also delays and at times total lack of communication on when and where donors should collect their donor card and blood screening results. From the prestudy, 48% of donors did not receive their screening results while 32% said they did not receive their donor cards after donation. This is attributed to lack of awareness of where to collect the results.

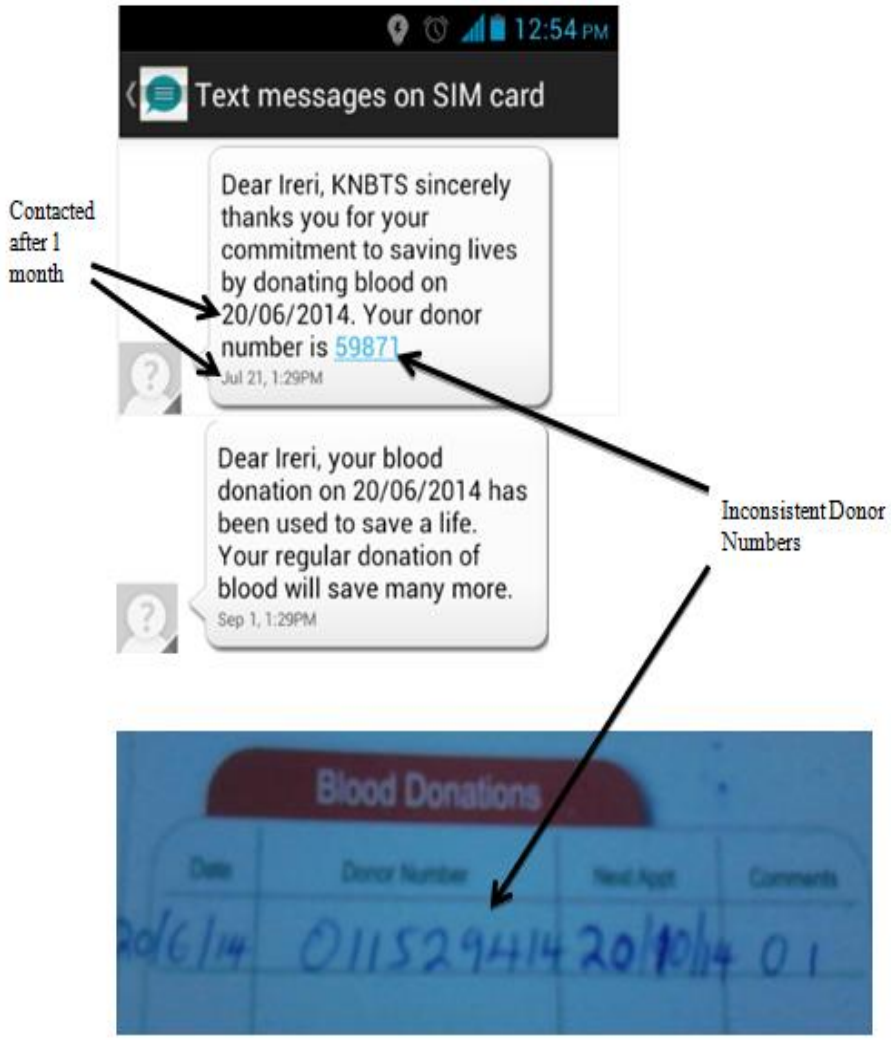

Figure 18: SMS messages from KNBTS

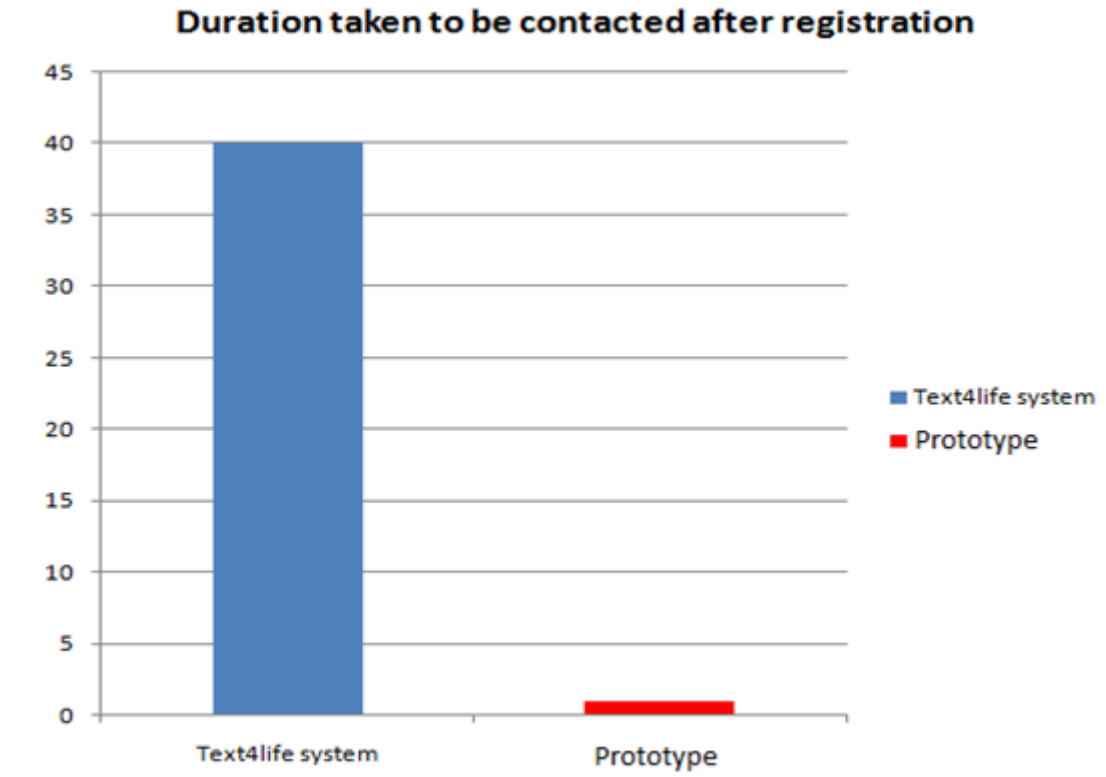

Figure 19: Time taken to contact donor after registration

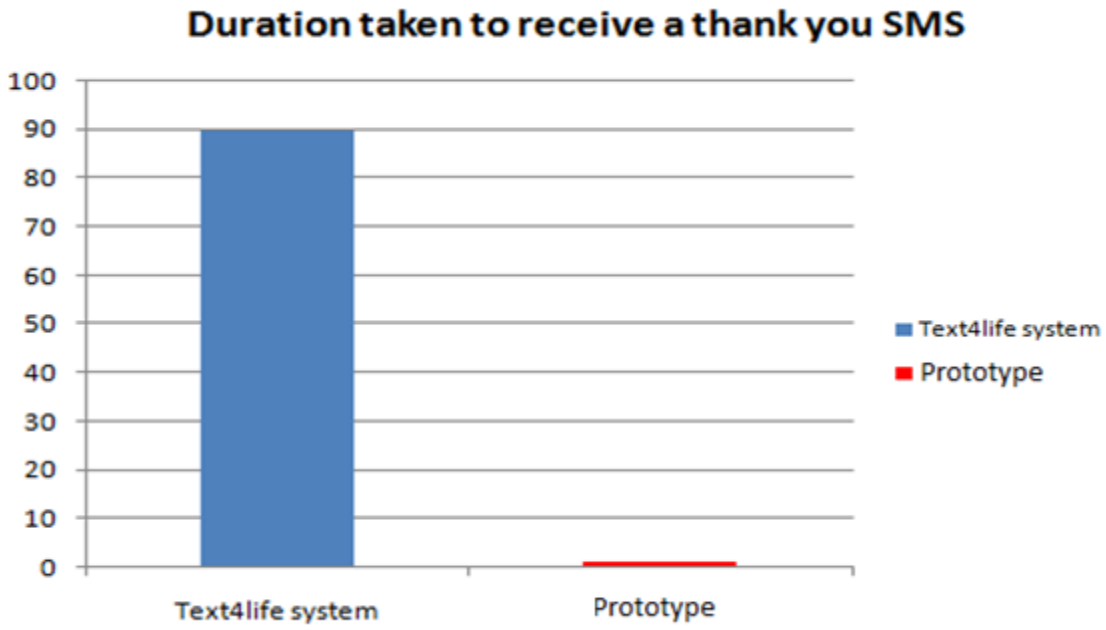

Figure 20: Time taken to that blood donor for donation

The above results explain (Figures 19 and 20) why respondents would prefer the prototype system as it enables them receive their registration details immediately they register. This is further evidence by the high number of respondents who strongly agreed (85%) and agreed (5%) that they appreciate receiving a donor registration via SMS and those who strongly agreed (80%) and agreed (20%) that they appreciate receiving a thank you note via SMS.

The study also sought to determine the respondent's satisfaction on receiving SMS notification indicating when and where to collect their donor card and blood test results. Majority of the responds (75%) strongly agreed while the remaining respondents (25%) agreed towards the use of a system that gives them information on when and where to collect their donor card and blood test results.

During the preliminary study, 51% of all donor respondents indicated that they did not receive their results while 26% of the donors waited for their results for more than two weeks.

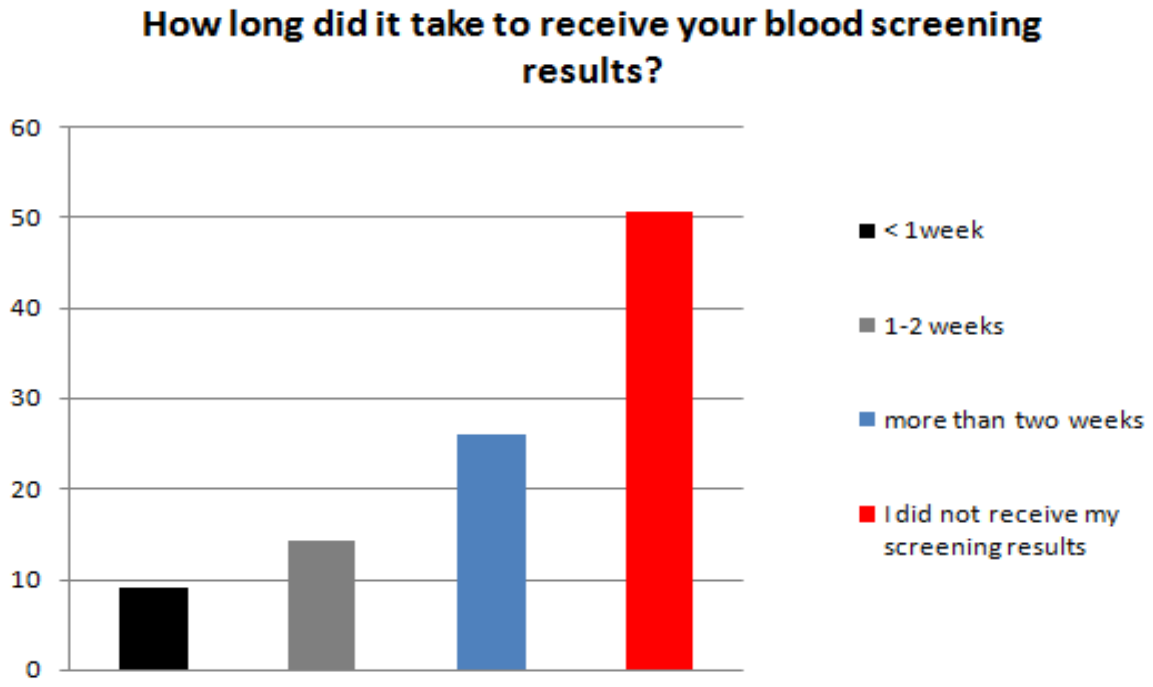

Figure 21: Time taken to receive blood test results

In addition the study also sought to ascertain the respondents' perception on whether the text messages on donation received via SMS have been educative. A high number of respondents

strongly agreed (50%) and an equivalent proportion agreed that the messages were indeed educative. One of the respondents commented:

"I was very shocked to know that 3 teaspoons of blood can save a baby's life."

Researchers have identified a range of socio-demographic, organizational, physiological, and psychological factors that influence people's willingness to donate blood. Findings from the prestudy confirm that these factors are the main reason people do not donate. Examples of these factors include: fear of needles, fear of experiencing temporary weakness and the belief that one does not have enough blood spare. For these reasons even when dates are communicated in advance people do not donate. Providing important and educative information to dispel fears and diffuse any misconceived myths and misunderstandings that have been prevalent and therefore increase donor turn outs during blood donor recruitment.

45% of the respondents indicated that they strongly agree with receiving notifications of donation dates and venues and that this information would help them plan ahead. More than 50% of the respondents agree that they are likely to share the educative SMS messages they receive because they find them useful, while 70% strongly agree that informative messages motivate them to keep donating. 55% of the respondents also strongly agree that the probability that they are more likely to donate after receiving donation notifications and educative information is high.

As part of the study, we also aimed to find out what other methods the respondents would like used to contact them. 50 % also like to be contacted via email while 30% think that social media is a great way of contacting donors.

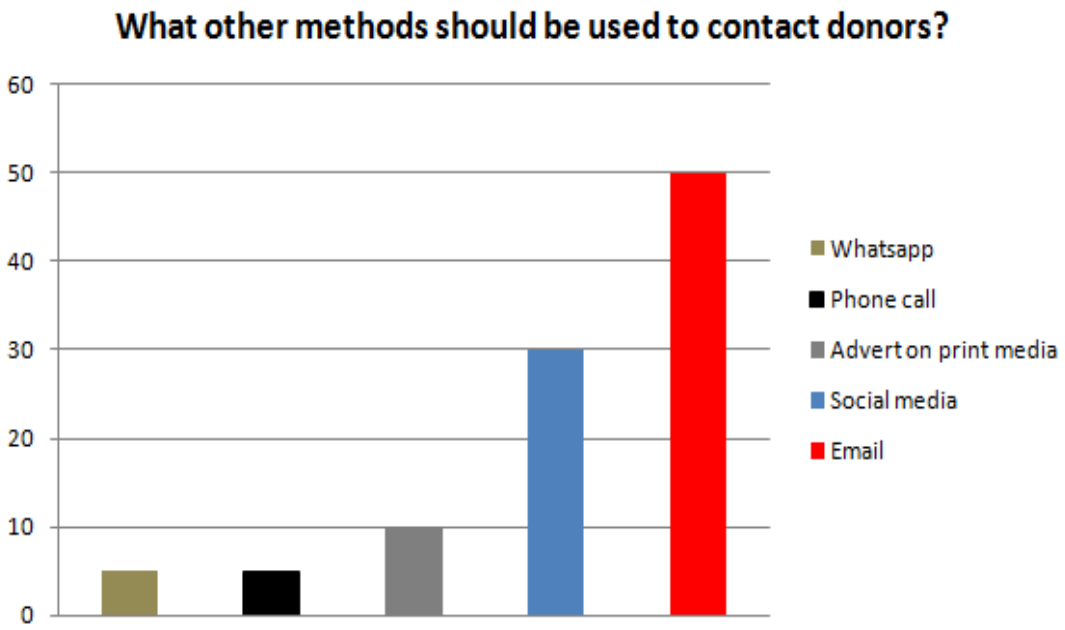

Figure 22: Methods to be used to contact donors

Once the respondents had a feel of what the system does, they were asked to suggest way in which the system can be improved.

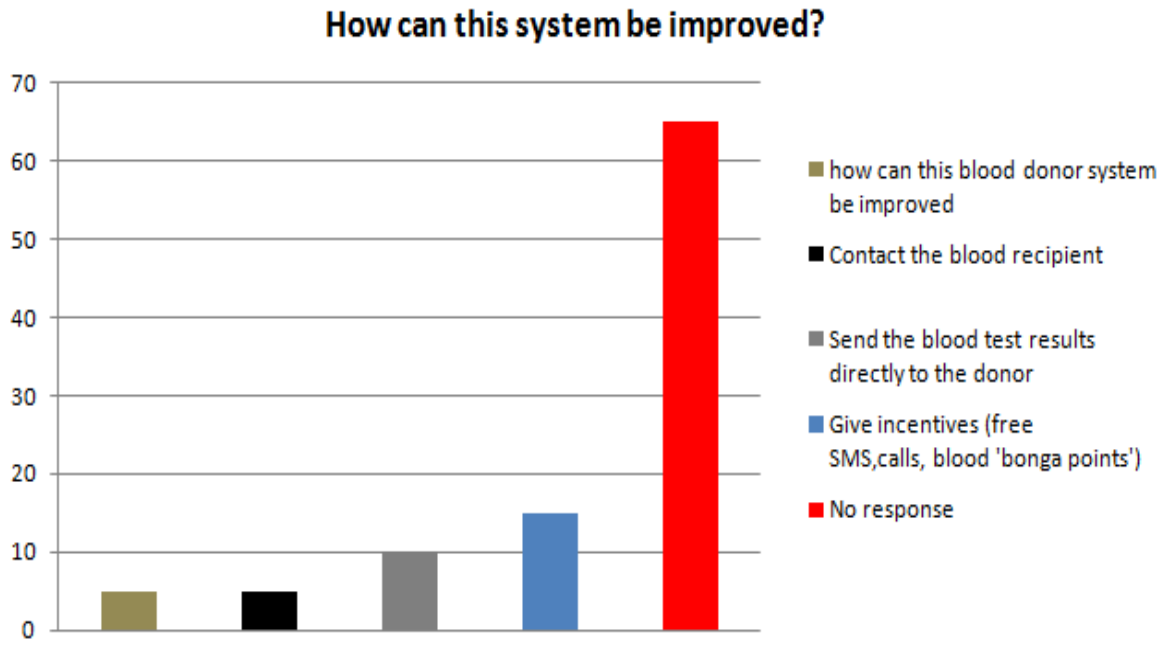

Figure 23: How can the prototype be improved

50% of all the respondents believe that by increasing donor education and public awareness donor turn outs and in turn increase the amount of blood collected.

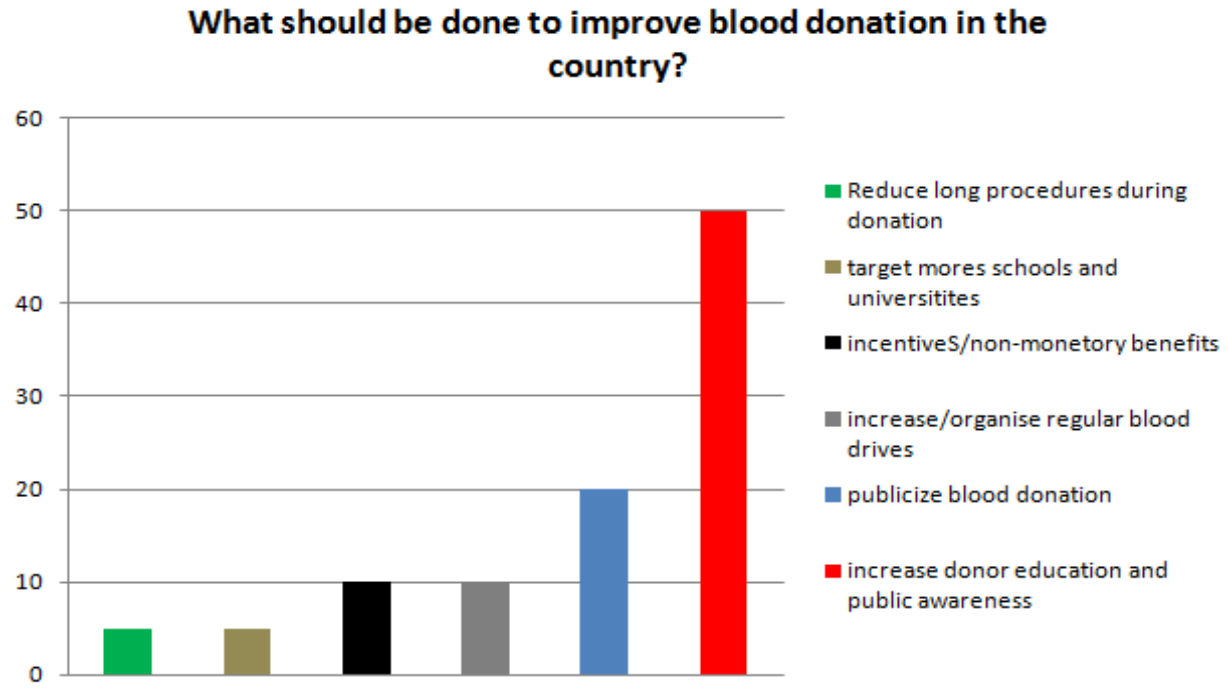

Figure 24: Improve donation in the country

Based on these test results, the registered donors appreciate receiving notifications and educative SMS messages through this system and are now more likely to attend donation drives and donate and share the knowledge they receive with friends and family.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

To our knowledge, no studies had previously been conducted on people's perception of blood donation in Kenya. The prestudy indicated that there is an information gap when it comes to blood donation in Kenya. Current systems are not donor-centered and therefore are not well placed in nurturing a longer term relationship between the donor and the Blood transfusion service. Clearly they miss out on the point that, without the donor there is no blood.

The developed prototype is a donor information needs driven system and therefore takes into account what the donor needs are in order to feel self-sufficient during the donation process. It is an interactive system through which the donor can not only receive information, but also ask questions that he or she may need answered in a timely manner.

This system offers useful information to blood donors in a timely manner which the respondents indicated they were quite satisfied with.

6.2 Limitations of the Study

The following are the limitations of this research project:

- Data collection at the KNBTS offices requires a letter of ethical approval from the medical ethics committee which takes several weeks which therefore limited the access to information needed to perform the preliminary study
- KNBTS has six regional offices and no county offices despite being under the Ministry of Health which is now devolved. Data collected therefore does not give a representation of the situation at the county level, but at the KNBTS regional level
- KNBTS has all its donation and transfusion records in paper form and most of the data is redundant and therefore inaccurate. Statics from the KNBTS are mostly estimates and approximations
- No prior research studies on the topic of the perception of blood donation have been conducted in Kenya and therefore a preliminary study had to be conducted to identify issues that cause law donation rates in the country

6.3 Recommendations for Future Works

- Respondents involved in the testing of the prototype suggested that they would like to be contacted via email and social media. Some also indicated that they would like to also receive SMS messages in Kiswahili
  - The use of a social media, text messaging and email based system to enhance donor recruitment, retention and provide blood donor education would increase the donor base especially if they received information in their preferred language.
- This solution can also be scaled up to a national level distributed blood and donor management systems that not only concentrates on blood and donor management at the transfusion service or health facility level but also allows different facilities to share information on donors and the different blood types
  - Allow the tracing of patients who have donated at a different facility before
  - Allow the sharing of information between health facilities on the blood types that are always in short supply but on high demand.
- Feedback from the system should take into account the changing donor needs. Since donors can interact with the system by sending their inquiries via SMS to the system, a frequently asked questions (FAQ) section can be created where similar questions can be grouped together and the FAQ answering automated.

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APPENDIX 1 : BLOOD DONATION PERCEPTION QUESTIONNAIRE

All questions contained in this questionnaire are part of a survey on public perception of blood donation. This survey aims to capture the knowledge, attitude and practice of both voluntary blood donors and those who do not donate blood. This survey should only take 5-10 minutes of your time.

INSTRUCTIONS: Please respond by placing a cross or a tick in the relevant box and explain briefly where required. Kindly answer as truthfully as possible.

Age:	☐ 16 - 20	☐ 26 - 30	☐ 36 - 40	☐ 46 - 50	☐ 56 - 60	**Gender:**	☐ M
	☐ 21 - 25	☐ 31 - 35	☐ 41 - 45	☐ 51 - 55	☐ 61 - 65		☐ F

Highest level of education:	☐ Primary		
	☐ Secondary		
	☐ Tertiary (Please specify)	☐ Vocational/technical school	☐ Doctoral degree
		☐ College	☐ Other (Please Specify)
		☐ Bachelor's degree	
		☐ Master's degree	

Marital status:	☐ Single	☐ Divorced / Separated
	☐ Married	☐ Widowed

Have you ever donated blood?	☐ Yes	☐ No

IF YES PLEASE ANSWER PART A, IF NO PLEASE ANSWER PART B OF THIS QUESTIONNAIRE

PART A (Please complete this section only if you have donated blood before, otherwise, proceed to PART B)

1. Was your donation voluntary?		☐ Yes	☐ No
2. Where have you donated blood? (Tick all that apply)	☐ Blood Donation Drive (Please specify)	☐ Campus / School	
		☐ Work	
		☐ Street	
	☐ Hospital		
	☐ Other (Please specify)		
3. At what age did you first donate blood? (Please Specify)			
4. How often do you donate blood?	☐ I donated once only	☐ Annually	☐ 1 – 3 times a year
	☐ more than 3 times a year	☐ I donate once in a while	
5. What motivates you to donate? /Why did you donate? (Tick all that apply)	☐ It is noble		
	☐ It saves lives		
	☐ I took a friend to go donate and decided to donate		
	☐ A friend or relative needed blood		
	☐ To find out my screening status i.e. blood group and status (HIV,Syphilis,HepB&C)		
	☐ I received a phone call from the blood center		
	☐ I received a text message from the blood center		

		☐ I received an email from the blood center
		☐ I was recruited at school / workplace
		☐ I read a post on Facebook / Twitter
		☐ I saw / heard an emergency appeal in the newspaper / TV / radio
		☐ I saw / heard an advertisement in the newspaper / billboard / TV / radio
		☐ Other (Briefly explain)
6. When you went to donate, how long did it take:	You to register and undergo physical test (i.e. checking weight, pressure etc)	☐ less than 10 Minutes
		☐ 10-20 Minutes
		☐ I do not remember
	You to donate?	☐ 10-20 Minutes
		☐ 20-60 Minutes
		☐ I do not remember
	Before you received a donor card?	☐ I received a donor card the same day I donated
		☐ 1-2 Weeks
		☐ More than 2 Weeks
		☐ I did not receive a donor card
	Before you received your screening results (these include: blood group and status: HIV, Syphilis, Hep B&C)	☐ I received my screening results the same day I donated
		☐ 1-2 Weeks
		☐ More than 2 Weeks
		☐ I did not receive my screening results
7. What did you learn and what information was shared with you by the donation officials during the donation process? (Briefly explain)		
8. What was your experience interacting with the blood donation officials? (Briefly explain)		
9. Based on your experience would you donate blood again?		☐ Yes ☐ No
10. Do you encourage friends and relatives to donate?		☐ Yes ☐ No
11. If not, briefly explain why.		
12. Do you know the common blood groups?		☐ Yes ☐ No
13. Do you know your blood group?		☐ Yes ☐ No
14. How often can an individual donate blood?		
15. Who should donate blood?		
16. After donating, were you contacted by the blood center / donation official?		☐ Yes ☐ No
17. If yes, why were you contacted and what information did you receive from the blood center / donation official? (Briefly explain)		

18. What method was used to contact you?	☐ Phone Call	☐ Text message	☐ Email
19. What feedback would you like to receive from the blood center once you have donated blood? (Briefly explain)			
20. Would you like to receive educative information on blood donation via text message or email?		☐ Yes	☐ No
21. Would you like to be contacted via text message or email for notifications on when and where blood donation drives are being held?		☐ Yes	☐ No
22. Have you ever received a blood transfusion or any blood products?		☐ Yes	☐ No
23. Has a relative/ friend/ acquaintance ever received a blood transfusion or any blood products?	☐ Yes	☐ No	☐ I do not know

24. In your own opinion, why don't people donate blood? (Tick all that apply)	☐ Their health does not allow them to
	☐ They fear contracting infections
	☐ Lack of awareness of the importance of donating blood
	☐ They are too busy
	☐ They think they do not have enough blood to spare
	☐ They fear experiencing temporary weakness after donating
	☐ Lack of awareness of donation venues and dates
	☐ Their Religion forbids it
	☐ Their Cultural beliefs do not allow them to
	☐ They have not been approached to donate
	☐ They need to donate for friends or relatives in future
	☐ They fear of needles
	☐ They fear knowing their status (HIV, Syphilis, Hepatitis B & C)
	☐ They think the blood they donate may be sold
	☐ People who donate voluntarily do not get it when they need it
	☐ No remuneration / reward / payment
	☐ Other (Briefly explain)

25. The Kenya National Blood Transfusion Services (KNBTS) is unable to collect the 400,000 units of blood required by the country annually due to low donor turnouts. What do you think should be done to improve blood donor participation and encourage Kenyans to give blood regularly? (Briefly explain)

PART B (Please complete this section only if you have never donated blood. Otherwise, complete PART A)

1. Why haven't you donate blood? (Tick all that apply)	☐ My health does not allow me to
	☐ Donating blood has adverse effects
	☐ I can contract infections
	☐ I may experience temporary weakness or fall sick after donating

	☐ I am too busy
	☐ I feel I do not have enough blood to spare
	☐ Lack of awareness of donation venues and dates
	☐ My Religion forbids it
	☐ My Cultural beliefs do not allow me
	☐ I have not been approached to donate
	☐ I need to donate for friends or relatives in future
	☐ I fear needles
	☐ I fear knowing my status (HIV, Syphilis, Hep B&C)
	☐ Donated blood may be sold
	☐ People who donate voluntarily do not get it when they need it
	☐ No remuneration / reward / payment
	☐ Other (Briefly explain)

2. Do you know the common blood groups?	☐ Yes	☐ No	
3. Do you know your blood group?	☐ Yes	☐ No	
4. How often can an individual donate?			
5. Who should donate blood?			
6. Would you donate blood if called upon to do so?	☐ Yes	☐ No	☐ Maybe
7. If maybe, briefly explain why.			
8. Do you encourage friends and relatives to donate?	☐ Yes	☐ No	
9. If not, briefly explain why.			
10. Would you like to be contacted via text message or email for notifications on when and where blood donation drives are being held?	☐ Yes	☐ No	
11. Would you like to receive educative information on blood donation via text message or email?	☐ Yes	☐ No	
12. Have you ever received a blood transfusion or any blood products?	☐ Yes	☐ No	
13. Has a relative/ friend/ acquaintance ever received a blood transfusion or any blood products?	☐ Yes	☐ No	☐ I do not know
14. The Kenya National Blood Transfusion Services (KNBTS) is unable to collect the 400,000 units of blood required by the country annually due to low donor turnouts. What do you think should be done to improve blood donor participation and encourage Kenyans to give blood regularly? (Briefly explain)			

APPENDIX 2 : BLOOD DONOR INFORMATION NEEDS QUESTIONNAIRE

All questions contained in this questionnaire are part of a survey on the use of an ICT based blood donor information needs driven system to improve blood donor participation. This survey aims to find out if donor information needs are met through the use of this prototype system. This survey will only take 5 minutes of your time.

INSTRUCTIONS: Please respond by placing a tick in the relevant box and explain briefly where required. Kindly respond as truthfully as possible.

Did you receive any feedback once you registered as a blood donor?	☐ Yes	☐ No

After registration, how long did it take you to get a response? (Tick the appropriately)	☐ less than 5 minutes
	☐ 1-7 days
	☐ more than 1 week
	☐ I was not contacted

What information / feedback did you receive? (Tick all that apply)	☐ **Registration Confirmation**
	☐ **Thank you message for blood donating**
	☐ **When and where to collect donor card and blood test results**
	☐ **Educative information on blood donation**
	☐ **Venue and date for your next blood donation**
What other information / feedback would you like to receive once you have donated blood?	

How satisfied are you with the information you received as an SMS on your phone? (Tick appropriately)	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I appreciated receiving my blood donor registration confirmation via SMS					
I appreciated receiving an SMS thanking me for my blood donation					
I appreciated receiving an SMS indicating when and where to collect my donor card and blood test results					
The text messages on donation received via SMS have been educative					
Receiving the venue and date for my next donation in advance as an SMS can help me plan when and where I will go donate					
I am likely to share these educative SMS messages on Blood donation with a friend					
The informative SMS messages will motivate me to keep donating					
I am now more likely to donate blood after the informative messages I received unlike before					

If you strongly disagree / disagree, briefly explain why.

The system uses text to communicate with donors, what other method should be used to contact donors?
In your opinion, how can this blood donor system be improved?
Blood donations rates in Kenya are low. In your opinion, what should be done to improve donation in the country?

APPENDIX 3 : USER MANUAL

Donor Registration

Once the potential donor is at the blood drive he/she is registered as a blood donor on the form below. As soon as the donor is registered, they receive an SMS confirmation message as follows:

"Dear Donor, you successfully been registered to the blood bank."

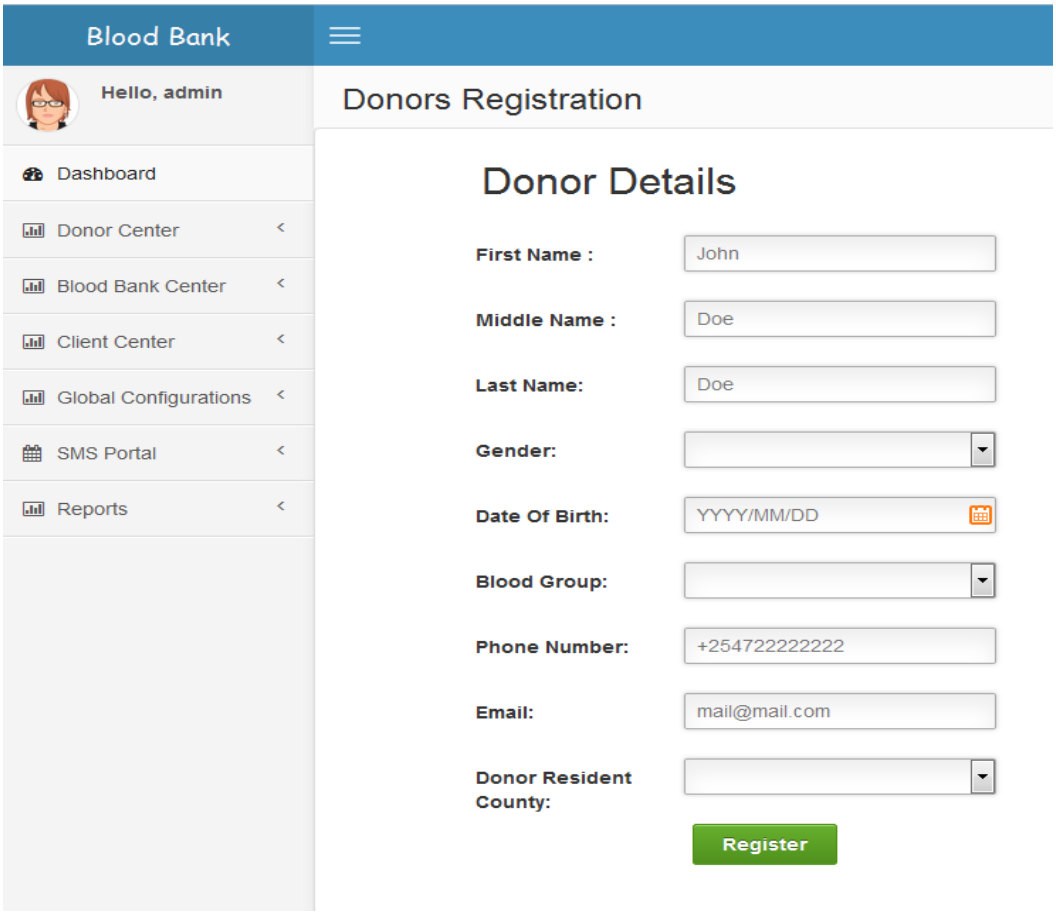

Figure 25: Donor Registration

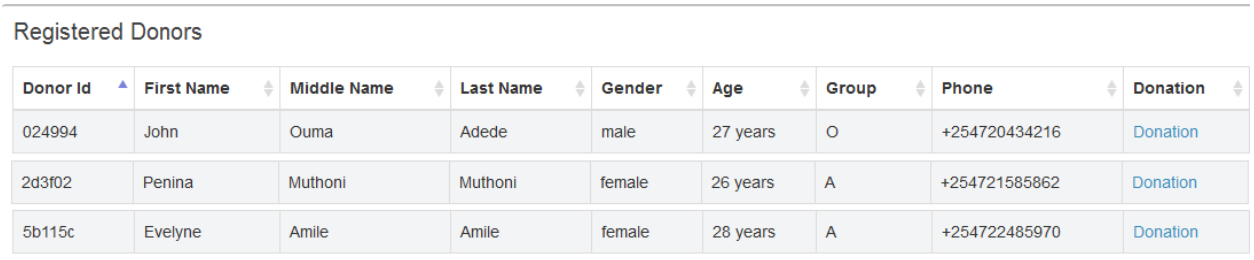

Figure 26: List of registered donors

Donations

A registered donor can now donate blood. The form below is used to enter the donor's donations details such as the amount they have donated and their date of donation. The donor also receives a thank you note immediately after they have given blood.

"Dear Donor, thank you for donating blood."

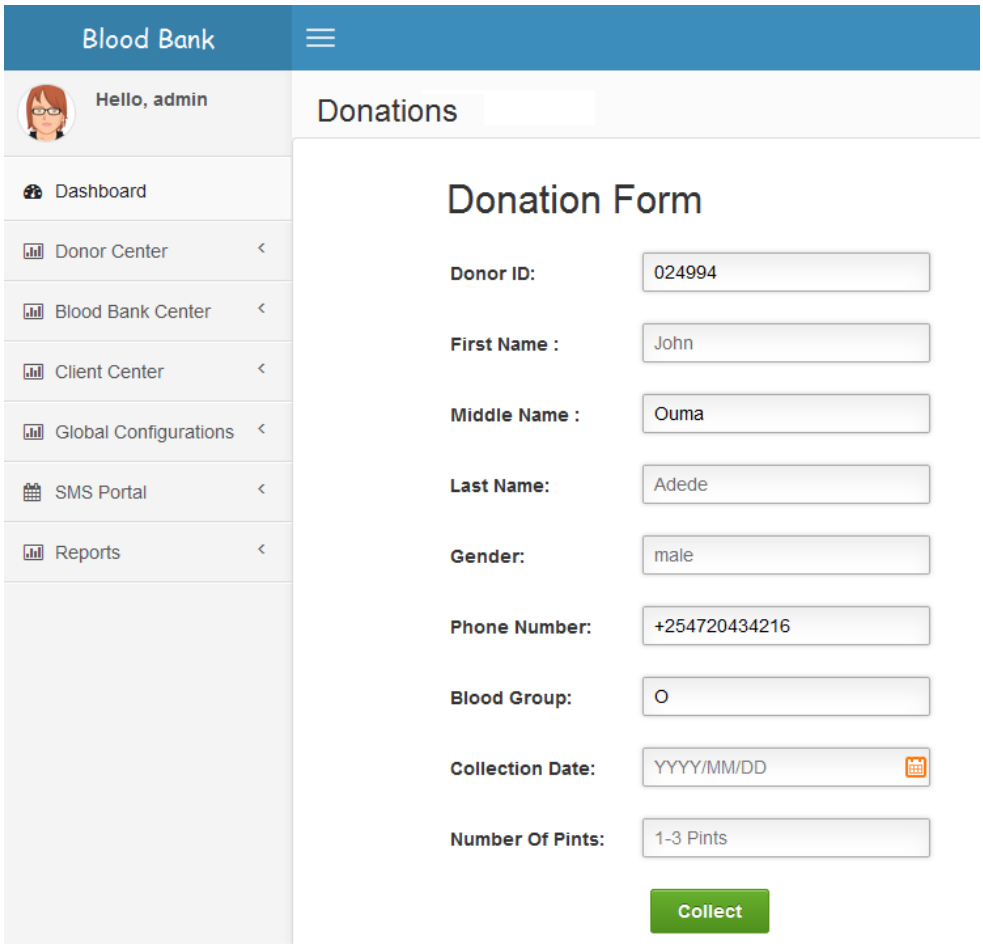

Figure 27 : Donations

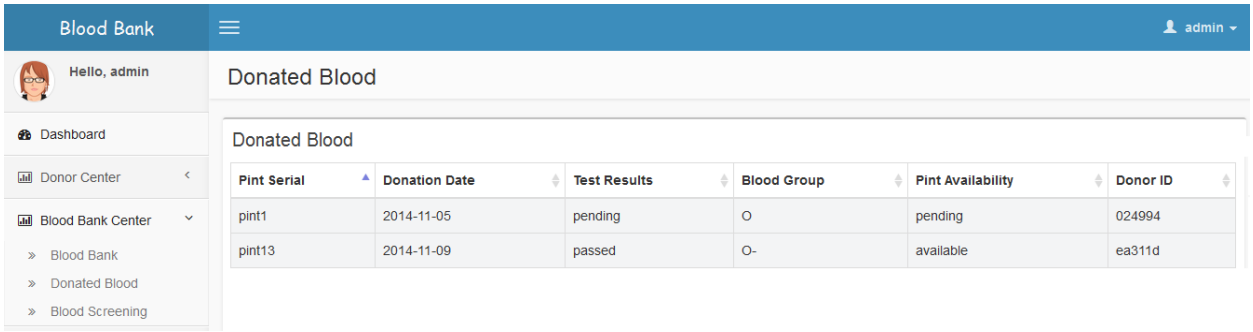

Figure 28: Donated blood

Blood Test Results

Donated blood is the screen to find out the donors blood group, and whether it is good for use by checking for presence of infectious diseases such as HIV, Hepatitis and Syphilis. Immediately the blood is tested, the donor then receives an SMS message informing them of when and where to collect their results, during which they receive a donor card.

"Dear Donor, your blood test results have been processed. Kindly come and collect them at the blood center. Results collection times are Mon-Friday 9am-5pm. Thank you for your donation."

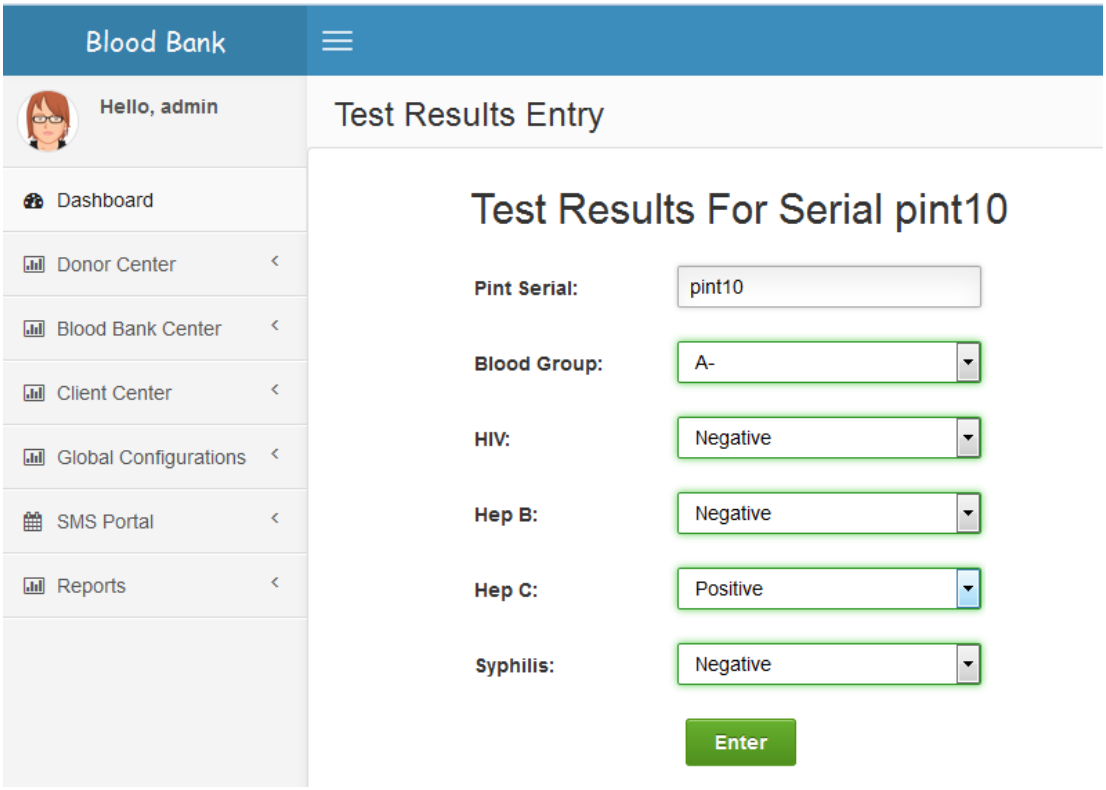

Figure 29 : Test results

Blood Bank

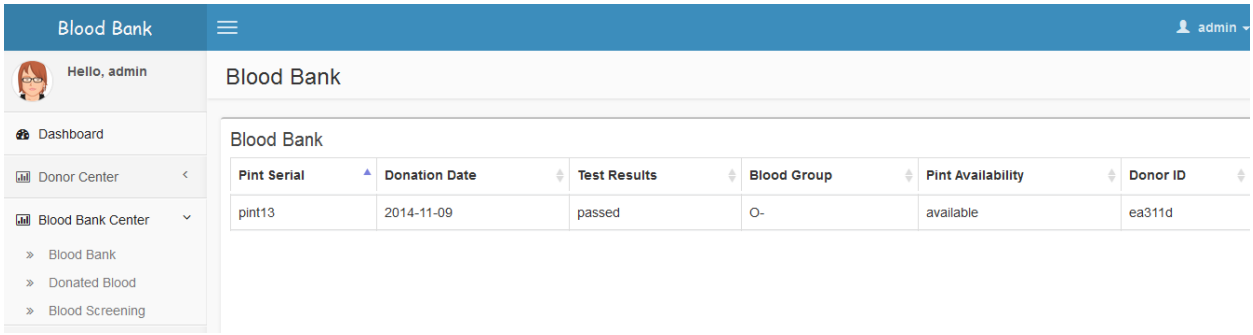

Figure 30 : Blood Bank

SMS Portal

The system administrator can send SMS messages to either one or all donors to inform them of a blood donation drive or send the educative information. SMS messages can also be send to registered hospitals which are in need of blood.

"As little as 3 teaspoons of blood can save the life of a baby and a pint of blood can save as many as three lives.Donate today and save a life!"

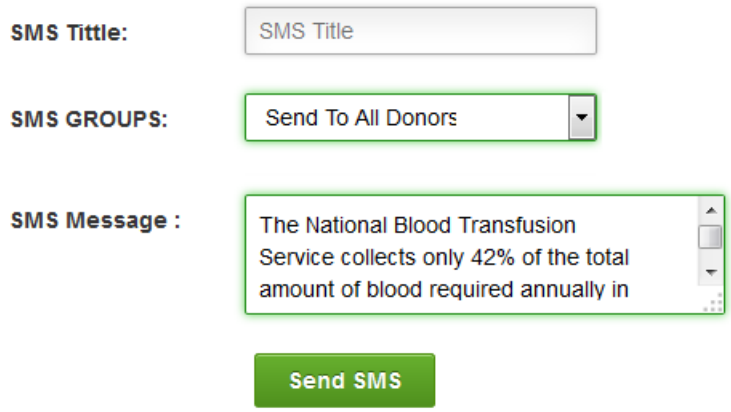

Figure 31 : Draft Message

Sent messages

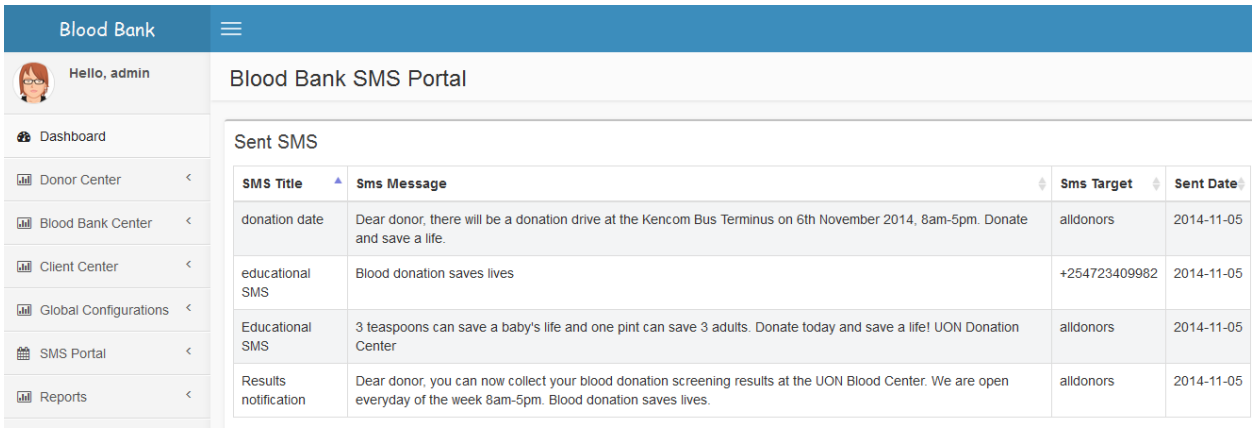

Figure 32: Sent Messages

SMS Inbox

Donors can also reply to received messages and send SMS messages with queries they may have to the blood centre number.

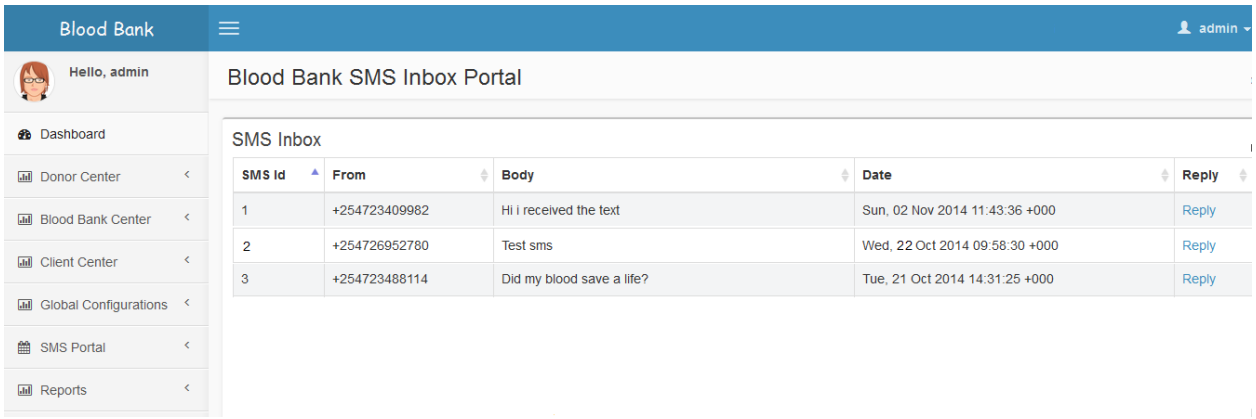

Figure 33 : SMS Inbox

APPENDIX 4 : CODE

SMS Code

```
<?php if ( ! defined('BASEPATH')) exit('No direct script access allowed');

class SMS extends CI_Controller {
        function __construct() {
        parent::__construct();
        $this->load->helper('url');
        $this->load->model('user_model');
        $this->load->model('hospital_model');
        $this->load->model('donor_model');
        $this->load->model('sms_model');
    }
        public function index(){
        if($this->session->userdata('logged_in')){
            $session_data = $this->session->userdata('logged_in');
            $group = $session_data['uacc'];
            if ($this->module_auth($group,'sms')) {
                $data['page']='sms';
                $data['username']=$session_data['username'];
                $data['sms']=$this->sms_model->get_all();
                $data['groups']=$this->hospital_model->get_all_bloodgroups();
                $data['scripts']='template/date_script';
                $this->load->view('template',$data);
            }else{   $this->load->view('noaccess');
            }
       }else{   redirect('login','refresh');
       }
    }
    public function send(){
        if($this->session->userdata('logged_in')){
            $session_data = $this->session->userdata('logged_in');
            $group = $session_data['uacc'];
            if ($this->module_auth($group,'sms')) {
                $number=$this->input->post('number');
                $message=$this->input->post('message');
                $title=$this->input->post('title');
                if ($number!='alldonors'&& $number!='allhospitals' &&
$number!='county' && $number!='bloodgroup' && $number!='combined') {
                    $this->single_sms($number, $message);
                    $this->sms_model->sent_sms($title,$message,$number);
                } elseif($number=='alldonors'|| $number=='allhospitals') {
                    $targets=$this->sms_model->get_numbers($number,'','');
                    $this->bulk_sms($targets, $message);
                    $this->sms_model->sent_sms($title,$message,$number);
                }elseif($number=='county'){
                    $targets=$this->sms_model->get_numbers($number,'',$this-
>input->post('county'));
                    $this->bulk_sms($targets, $message);
                    $this->sms_model->sent_sms($title,$message,$number);
                }elseif($number=='bloodgroup'){
                    $targets=$this->sms_model->get_numbers($number,$this-
>input->post('bloodgroups'),'');
                    $this->bulk_sms($targets, $message);
```

```
                    $this->sms_model->sent_sms($title,$message,$number);
                }elseif($number=='combined'){
                    $targets=$this->sms_model->get_numbers($number,$this-
>input->post('bloodgroups'),$this->input->post('county'));
                    $this->bulk_sms($targets, $message);
                    $this->sms_model->sent_sms($title,$message,$number);
                }
                redirect('sms');
            }else{  $this->load->view('noaccess');
            }
        }else{    redirect('login','refresh');
        }
    }
    function bulk_sms($phone, $message){
        require('Services\Twilio.php');
        $account_sid = 'AC0c30e6a0cf4b0a8705608ce03598d3a6';
        $auth_token = '20dfb2457b6486f767fb382f3433bbee';
        $client = new Services_Twilio($account_sid, $auth_token);
        foreach ($phone as $num) {
            $client->account->messages->create(array(
                'To' => "$num",
                'From' => "+17064084305",
                'Body' => "$message",  ));
        }
    }
    function single_sms($phone, $message){
        require('Services\Twilio.php');
        $account_sid = 'AC0c30e6a0cf4b0a8705608ce03598d3a6';
        $auth_token = '20dfb2457b6486f767fb382f3433bbee';
        $client = new Services_Twilio($account_sid, $auth_token);
        $client->account->messages->create(array(
            'To' => "$phone",
            'From' => "+17064084305",
            'Body' => "$message",  ));
    }
    function sms_inbox(){
        if($this->session->userdata('logged_in')){
            $session_data = $this->session->userdata('logged_in');
            $group = $session_data['uacc'];
            if ($this->module_auth($group,'sms')) {
   // this line loads the library
                require('Services\Twilio.php');
   // Your Account Sid and Auth Token from twilio.com/user/account
                $sid = "AC0c30e6a0cf4b0a8705608ce03598d3a6";
                $token = '20dfb2457b6486f767fb382f3433bbee';
                $client = new Services_Twilio($sid, $token);
   // Loop over the list of messages and echo a property for each one
                $this->sms_model->truncate();
                foreach ($client->account->messages as $message) {
                    if ($message->direction=='inbound') {
                        $this->sms_model->inbox($message-
>date_created,$message->from,$message->body);
                    }
                }
                $data['page']='smsinbox';
                $data['username']=$session_data['username'];
                $data['sms']=$this->sms_model->get_inbox();
```

```
                $data['scripts']='template/date_script';
                $this->load->view('template',$data);
            }else{  $this->load->view('noaccess');
            }
        }else{   redirect('login','refresh');
        }
    }
    function get_sms(){
 // this line loads the library
                require('Services\Twilio.php');
 // Your Account Sid and Auth Token from twilio.com/user/account
                $sid = "AC0c30e6a0cf4b0a8705608ce03598d3a6";
                $token = '20dfb2457b6486f767fb382f3433bbee';
                $client = new Services_Twilio($sid, $token);
 // Loop over the list of messages and echo a property for each one
                foreach ($client->account->messages as $message) {
                    if ($message->direction=='inbound') {
                        //print_r($message)
                        echo $message->from."string </br>";
                    }
                }
    }
    function reply($number,$message){
        if($this->session->userdata('logged_in')){
            $session_data = $this->session->userdata('logged_in');
            $group = $session_data['uacc'];
            if ($this->module_auth($group,'sms')) {
                $data['page']='reply';
                $data['number']=$number;
                $data['message']= str_replace('%20', " ", $message);
                $data['username']=$session_data['username'];
                $data['scripts']='template/date_script';
                $this->load->view('template',$data);
            }else{   $this->load->view('noaccess');
            }
        }else{    redirect('login','refresh');
        }
    }
    function smsreply(){
        if($this->session->userdata('logged_in')){
            $session_data = $this->session->userdata('logged_in');
            $group = $session_data['uacc'];
            if ($this->module_auth($group,'sms')) {
                $this->single_sms($this->input->post('number'), $this->input-
>post('reply'));
                redirect('sms/sms_inbox');
            }else{   $this->load->view('noaccess');
            }
        }else{    redirect('login','refresh');
        }
    }
    public function module_auth($group,$name){
        return $this->user_model->module_acc($group,$name);
    }
}
```