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Enhancing Blood Products Sharing Among Established Blood Banks and Health Facilities through the use of ICT

Moses M. Wainaina
School of Computing and Informatics, University of Nairobi,
Box 30197, Nairobi, Kenya

Peter W. Wagacha
School of Computing and Informatics, University of Nairobi,
Box 30197, Nairobi, Kenya

George N. Wainaina
School of Computing and Informatics, University of Nairobi,
Box 30197, Nairobi, Kenya

Abstract: The gap between blood supply and blood demand is a widening everyday as the population increases and it needs to be bridged. Since the amount blood donated in Kenya is below the world Health Organization's recommendation (WHO 2015), inter-facility sharing of information relating to blood availability should be enhanced to improve sharing of available donated blood between health facilities.

The objective of the research study was to determine the current processes used when sharing blood between health facilities and there challenges and to propose coordination between blood supply and demand among health facilities and blood banks through the use of ICT .The study used descriptive research design and 22 participants (lab technicians and doctors) in different health facilities in Nairobi County participated in the study.

Results from the study indicate that in most health facilities (72%) blood demand exceeds blood supply. During emergencies when blood stocks are inadequate, most health facilities (63.6%) source the blood by requesting it from other health facilities and blood banks and mostly making these blood requests through telephone calls. The main challenge faced when using the current mechanisms is the delay in blood supply (40.9%) followed by a challenge of getting the response/feedback on time

Based on the findings it was evident that the proposed intervention will be of a great use to bridge the gap of between blood supply and demand and solving the challenges faced when sharing blood during emergencies. Rapid Application Development (RAD) system design AND Service Oriented Architecture (SOA) were applied in developing the ICT intervention. To evaluate the success of the ICT intervention, a survey was conducted in five health facilities (two level 4 and three level 3 health facilities) to evaluate the satisfaction of the health facilities when using the system.

Keywords: Blood, Blood banks, health facilities, blood sharing, ICT.

1. INTRODUCTION

Timely access to secure blood and blood products is part of the WHO's global health agenda and global strategic priorities (WHO Regional Office for Africa, 2009). Blood is considered as a very important product in healthcare services because most surgical and emergency activities in hospitals depend on blood transfusion thus sufficient blood distribution and supply in timely manner to hospitals is most essential activities to enhancing health care (Tapko 2006). Currently in the world the availability of integrated health care system is important in enhancing emerging medical response (Mwangi 2017). According to WHO 2015 the world is making significant steps to reduce the mortality rate caused by diseases and emergencies like accidents, however this is only being experiences in developed country hence more effort need to be enhanced in developing and undeveloped countries. Development and expansion of Information

and Communication Technology in healthcare management has been the trend in developing and innovating health solution in all the parts of the word since 21st century (Kumar 2003). Specifically, according to (GUO 2009) ICT plays a major role in managing blood donated in blood banks as well as in health facilities.

Access to safe blood in convenient time can prevent many deaths especially in developing countries. One pint of blood (450ml) can save 3 lives while teaspoon of blood can save one baby's life (Ireri 2014). For instance according to WHO 2014 almost 800 women lose their lives daily in the world due to complications of pregnancy and childbirth. 27% of these women bleed to death before, during and after giving birth. So if blood readily available in convenient time some such kind of deaths can be avoided.

Kenya acknowledged the importance of coming up with a national blood service that agrees with WHO proposals and World Health Assembly (WHA) declarations suggestions were used to made regional system of transfusion centers managed by central coordination in 1994. In the year 2001 Kenya's initial blood policy plan was established and opened the first Regional Blood Transfusion Center (RBTC) and national management office was set up in Nairobi (Kenya National Blood Transfusion Service, 2012).

In Kenya KNBTS collects, tests, process and distribute blood and blood products to all transfusing health facilities in the country. Mostly Non- government organization like Kenya Red Cross (KRC) and Hope Worldwide Kenya drives the processes of awareness, mobilizing and recruiting blood donors in Kenya. National Management of blood and transfusion services in Kenya is carried out by the Kenya National Transfusion Center at the Kenyatta National Hospital (KNH) which processes blood and make it available to the blood banks and health facilities located all over the country.

According to KNBTS report (2013) Kenya needs 400,000 units every year to be blood sufficient. However KNBTS acknowledged that it has failed to hit its target of 180,000 units as visualized in the period ending December 2017. In lieu KNBTS collected 149,000 units. Since there is increasing in demand for blood products as donor population decreases, supply chain for blood to and between health facilities should be enhanced to save lives (seifried et al 2011).

2. OBJECTIVES

The study aims in at developing a solution that will help to bring about proper coordination between blood supply and demand among health facilities and blood banks by enhance sharing of these blood products between them.

The specific objectives:

i. To investigate the availability of blood in health facilities.
ii. To evaluate current process and methods used when sharing of blood products between blood banks and health facilities and there challenges.
iii. To design and develop a web based system that provides timely information to health facilities about the availability of blood and blood products in blood banks and health facilities
iv. To evaluate the prototype by involving lab technicians and doctors in health facilities

Blood and blood products

The most important blood groups among more than 30 major blood group systems are blood group systems ABO and RhD when

referring blood donation and blood transfusion (Ireri 2014). The blood groups are determined on the surface of red cells by the protein known as antigen. Blood group of a person is defined by both ABO and RhD blood groups. For example a person whose ABO blood type is B and RhD is negative(-) , that blood group is known as blood group B- .A person may have ABO blood group A, blood group B, blood group AB or blood group O Whereby RhD can only be positive (+) or negative (-).

According to (Repine 2006), most common blood products used for blood transfusion are Red Blood Cells (RBC), whole blood, platelets, plasma and cryoprecipitate (frozen plasma). These blood products have different shelf lives depending on the kind of the storage used (type of blood bag used and the temperature of storage area). For instance the expiry date for Red Blood Cells (RBC) depends on the type of anticoagulants and addictive solution used (Rubin 2011). The shelf life of whole blood is 35-42 days, Red Blood Cells are 42 days, platelets are 5 days, plasma is 48 hours and cryoprecipitate the shelf life is up to 1 year.

Blood supply chain

According to A.F. Osorio et al (2015), blood supply chain contain the following processes ;collecting, testing, processing and distributing blood and blood products from donor to recipient. Mainly in the countries where there are regional and national systems, blood is transported between blood centers and health facilities and also between health facilities. Since there increasing in demand for blood products as donor population decreases, supply chain for blood to health facilities remain the important factor (seifried et al 2011).

ICT for blood bank management

Alfred et al (2012) indicated blood can be stored in health facilities for varying amount of time, this can be from a few days, months or even years and the unused amount of blood is returned to the blood bank. Therefore due to reserving and undeserving blood in hospitals blood banks, ICT services are needed to keep records and transfer (share) information about the balance between the blood bank and health facilities (Kendall et al 2012). In his study about blood distribution in health facilities using ICT in South Africa, Alfred (2012) found that the blood shortage in the hospitals occurred frequently. However this problem of shortage of blood can be solved by ensuring every hospital blood bank contain sufficient through monitoring effectively using ICT. Also ICT according to Alfred (2012) can be used to prevent overstocking blood in a single hospital while other hospitals run out of stock and this can enhance supply of fresh blood in case of any emergencies in hospitals.

Sharing of blood products among health facilities in Kenya

Management of blood, blood products and blood transfusion services in Kenya is carried out by Kenya National Transfusion center at Kenya National Hospital (Kenya National Blood Transfusion Service, 2012). It processes blood and distribute it to the established blood banks and all over the country. Then the blood banks avail the blood for use to the health facilities.

Guidelines recommended by KNBTS when requesting blood for blood transfusion (KNBTS 2012)

i. Only qualified doctor my order blood but when there is emergency, blood may be requested by a nurse on doctor's behalf.

ii. Urgently samples and requests must be discussed directly through the phone and the form in the laboratory should be labeled URGENT.
iii. The laboratory shall record all requests made through the phone including patient's details, the requesting doctor and the person making the phone call.
iv. The laboratory will require a sample to issue any blood component
v. When there is extreme emergency blood group O negative blood will be issued because O negative can match with any other blood group in transfusion

Related work.

Australia's online blood ordering and inventory management system

Blood products sharing in Australia is managed by a system known as BloodNet. BloodNet is a web based system which enables staff in health facilities across Australia to be able order blood and blood products in a standardized way and to so quickly, easily and secure from Australian Red Cross Blood service (NBA 2011). Stock Movement dashboard in bloodNet allows transferring and discarding blood and blood products. BloodNet system also provides a predefined list of blood products that can be ordered by another health facility (NBA 2011). Australian Nation Blood Authority (NBA) enabled interfacing between laboratory Information System (LIS) and BloodNet system to abolish double-entry and to speed up the transfer of data and information between all stakeholders in the blood sector.

American Association of blood banks (AABB) – NBE Exchange web based system

AABB is the global leader in standard development accreditation and implementation of quality system in transfusion of medicine and cellular therapies. AABB has a program known as National Blood Exchange (NBE) that is mandated to provide important services to blood banking. NBE coordinates the distribution of more than 185,000 units of blood components in United States of America. (American Association of Blood Banks, 2018)

NBE Exchange web based system provides blood centers with the opportunity to have easily and efficient move surplus blood to areas that need the blood and provide health facilities with additional blood if the need is high compared to the current amount of blood available in hospital.

Blood Bank in India

The management information system (MIS) of blood bank in India allows health facility to request the blood when need arises from the blood bank. The blood bank keeps the following details; patient name, type of the blood group which requested, hospital name and its address, the name and the details of the doctor who request for blood and time and date the blood is needed. The blood bank system also provide the several criteria when searching for blood, these include city wise criteria and group wise criteria. (Makau 2014)

A Review of the related Frameworks

A framework of the blood transfusion chain in Netherlands

Van Hoeven LR et al (2016) proposed a framework that provides an overview of steps of the transfusion chain from the donor to the recipient in different hospitals. It identifies and highlights areas within the transfusion chain with a room for improvement. This framework presents four main applications

that are linked to the steps of the chain and identify the data that is necessary for each application. The applications used in this framework include.

i. Risk factors

ii. Predict future blood products needed

iii. Benchmark blood use

iv. Improve process efficiency

ICT Service Oriented Architecture (SOA) framework that enable blood distribution to health facilities in South Africa rural areas.

Afried, C et al (2012) in his study proposed Information Communication Technology (ICT) service oriented architecture framework to assist effective blood inventory management in rural hospitals in South Africa. The architecture encourages the integration of local hospitals services and availing the services to the web through a provincial e-health service hub. The framework includes the blood services of the health facilities and changes them from paper phase to the electronic phase through the service hub.

A Generic modeling framework to evaluate network blood management in Canadian blood service

Blake et al (2014) proposed a generic modelling framework to evaluate network blood management. Data from this generic modeling framework was derived from transaction level record extracted from Canadian blood service production database. This framework is useful in regional blood supply chain and blood distribution site in Canada. Data for the modeling framework was derived from transaction level records extracted from Canadian blood service production database. Information regarding all blood units produced, distributed or disposed at any distribution site in Canada between certain periods of time is obtained

A DSS (Decision Support System) Architecture to manage platelet production supply chain for regional blood centers

T.K sen (2010) proposed a DSS architecture that is optimized for delivery of platelets from production centers to transfusion centers (Health facilities). A decision support system is an information system that supports business or organizational decision-making activities. The DSS architecture assists the regional blood center manger to schedule the shuttle transportation and supply of whole blood from collection sites to the regional processing center.

Framework Adopted

The researcher adopted the ICT Service Oriented Architecture (SOA) framework that enables blood distribution to health facilities in South Africa rural areas

Reasons for adopting this framework

-It incorporates blood services in hospitals and transforms them from physical and paper phase to electronic / ICT phase

-It emphasizes the integration services within health facilities and avails these services to the web through E- health service hub.

-E- Health service hub in this framework is implemented using SOA architecture using web service interface which bring about

interoperability between health system and services connected.

-E-health service Hub provides set of integration blood services which gives connectivity amongst all health facilities and healthcare service.

Methodology

The nature of the this research was to identify current methods used when sharing blood products among health facilities and blood banks and identify they challenges faced when using this methods. In addition users were involved in designing and testing a web-based prototype to enhance sharing of these blood products between health facilities. Thus descriptive research method was applied employing a mix of both quantitative and qualitative approach.

A total of 24 health facilities/participants from Nairobi County purposely selected and 2 participants from one blood bank participated this research study. These health facilities were selected based on their geographical areas which span across the entire county. Purposive sampling technique was used: This method is important when the researcher needs to study a certain cultural domain with knowledgeable experts within. Questionnaires ad interviews were used to gather data from the selected participants. After the data collection, all the questionnaires were adequately checked for data verification. The data was be tabulated in the line with the objectives of the study. The tabulated data was subjected to both quantitative and qualitative analysis.

Quantitative data was be analyzed through descriptive statistics in the form of frequencies tallies and percentages. The statistics were generated using statistical package for social sciences (SPSS) and data obtained was presented through pie charts tables. Qualitative data was analyzed by organizing them in accordance with research questions and objectives

The responses received were positive in determining if coming up with the proposed intervention was a viable idea. The preferred methodology for the development of the prototype is Rapid Application Development (RAD).Also SOA was used in the system where REST web service server was applied requesting HTTP requests and getting the response to the user. The researcher did an evaluation on prototype functionality and usability to get the user perceptions of the prototype and how it can be improved to enhance process of blood sharing.

Scope of the study

The participants were doctors and lab technicians from health facilities in Nairobi County .The participants were to be selected based on their professional which is relevant to the study .In each health facility selected the researcher targeted one participants (24 health facilities *1=24). Also from Kenya National Transfusion Center the researcher targeted two participants. This gives a sample size of 26 participants. However the response rate was 85% which represents 22 participants out of targeted 26 participants. The participants were from ten level 3 health facilities, nine levels 4 health facility, two level 5 health facilities and one level 6 health

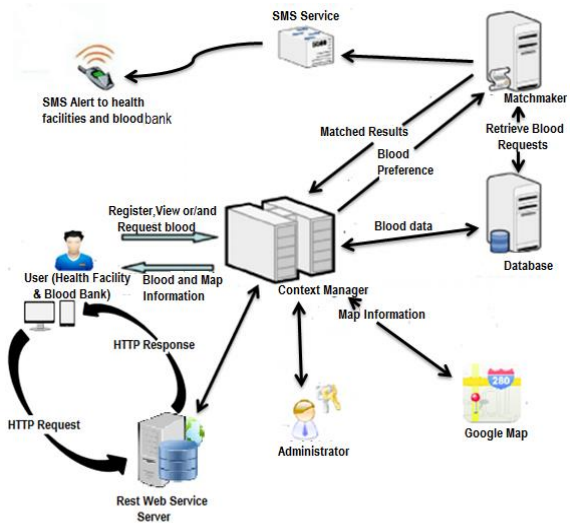
System description

System design

The proposed solution is a web based application that achieves proper cooperation between the blood banks, health facilities having them interacting with a single central database. The Proposed system is a responsive website hosted and on an apache web server. The system is deployed on a

central server while being accessing and collecting data from browsers on different devices in distributed areas. The system was designed to be used by different blood banks and hospitals. All functionality of the system will be accessible over the internet through a web browser.

When blood is donated in any health facility, the facility captures data about the blood products including the amounts and the date of blood donation. This is accessible to all health facilities and blood banks that want to request for these blood products in case of any emergency or shortage.



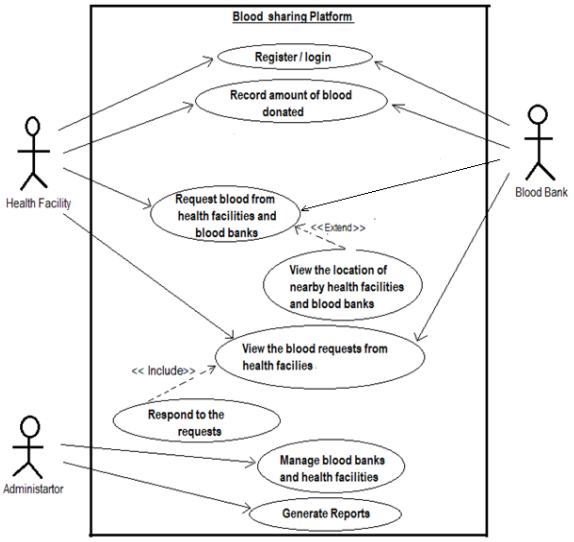
A conceptual representation of the perceived system architecture

The intervention includes Google maps to assist the health facility that require blood products to locate nearby blood bank or health facility that has the blood products needed. The SMS Alerts will be important when health facility request blood products. This will ensure the blood requests a received and being responded in timely manner thus convenient during emergencies situations in health facilities

System users

The system have three users namely; Health facility, Blood bank and the system administrator. The user Case below shows how system users interact with the system.

Use Case diagram



Implementation

Based on the intervention functional and non-functional requirements, technology design decision were made and the ICT intervention was implemented using the following technologies

-**HTML5 and CSS** for designing the web interface of the web application - these tools were used to code the system user interface (UI).

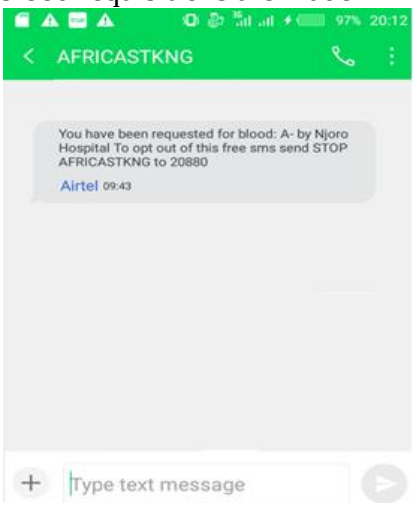
-**Laravel 5.3 a PHP framework and bootstrap 3** for developing server-side scripting codes front end- Laravel was used to strengthen security and speed up database migration without data loss. Tables were created to store, display, manipulate and delete database records. Forms were also

created to allow for user input and retrieval of data from the database.

-Microsoft SQL (Structured Query Language) Server for database design – MYSQL was used because it guarantees data security and integrity. MySQL database use primary keys hence avoiding avoids redundancies. The foreign keys in MySQL database aids in creating relationships between entities.

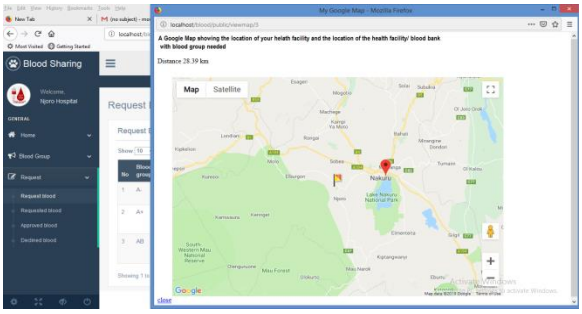
-Apache web server for hosting the application – Apache web server will make the system readily available to any health facility or blood bank. Also modification can be made to suit system users' needs

-Africa's Talking API Messaging – This was used to send effective alerts text messages and feedback SMS text messages when blood requisitions are made



A sample of a notification text message

Google maps API – This is to allow health facilities to locate the nearby health facilities or blood banks with the blood needed



A sample of a map showing the distance and location of the health facility with blood needed

Results

a) Sources of blood during emergencies when blood stocks are inadequate

During emergencies most health facilities (63.6%) request blood from other health facilities, followed by donation from patient's family member with a percentage of 27.3% and then 9.1% source the blood from donation campaign

	Frequency	Percent
Donation from patient's family member	6	27.3
Request blood from other health facilities	14	63.6
donation campaign	2	9.1
Total	22	100.0

b) Current process and methods used when sharing of blood products between blood banks and health facilities.

63.6 % of the health facilities reported they use telephone calls when requesting blood from other health facilities. 36.4 % reported to use blood requisition forms. The research study found that lab technicians or doctors in these health facilities are the one make calls and fill forms when requesting blood from various health facilities.

	Frequency	Percent
Telephone calls	14	63.6
Fill requisition forms	8	36.4
Text messages	0	0
Email	0	0
Total	22	100.0

c) Challenges faced when using current process and in requesting blood.

9 out of 22 respondents (40.9%) reported that when using current processes in requesting blood the main challenge they face is the delay in blood supply. 8 out of 22 respondents (36.4%) reported the main challenge is that it takes time to get the response/feedback, 7 out of 22 respondents (31.8%) reported the challenges faced are hard to know the nearby health facility with required blood and Inconvenience when keeping blood requisition record. Only 1out of 22 respondents reported that the current process is costly.

		Responses		Percent of Cases
		N	Percent	
	It takes time to get response/ feedback	8	25.0%	36.4%
	Hard to know nearby health facility with required blood	7	21.9%	31.8%
	It is costly	1	3.1%	4.5%
	Delay in blood supply	9	28.1%	40.9%
	Inconvenience when keeping records	7	21.9%	31.8%
Total		32	100.0%	145.5%

System evaluation

Evaluation was done to ensure that the system requirements were met. Five health facilities were used to evaluate the proposed ICT intervention: three level 3 health facilities and two level 4 health facilities

Functionality Evaluation

This was to access whether or not intervention/ system developed works the way it was intended.

All the five health facilities strongly agree that the system provides sufficient blood information from health facilities and blood banks; they get blood request alerts and feedback on time and them a satisfied with the system in enhancing blood products sharing with other health facilities. Four health facilities strongly agree that the system is easy to use while the other health facility only agrees. This was same to the functionality of locating nearest health facility or blood bank with the required blood easily through the Google maps in the system.

Discussion

Most health facilities indicated that blood demand exceeds supply and this shows that blood is highly needed in every health facility. Having over 90% of the respondents with facilities to store donated blood also shows that this vital product is on a high demand. The results shows that most health facilities, during emergencies, they request blood from other health facilities or blood banks. However it was noticed that there is a problem of delay in blood supply during sharing since the mechanism used by many health facilities is telephone calls where doctors or lab technicians make calls to the health facilities asking them if there is available blood in their blood banks. After the blood is shared health facilities keep the record in files and this also was indicated as one of the challenges when using the current processes and mechanism

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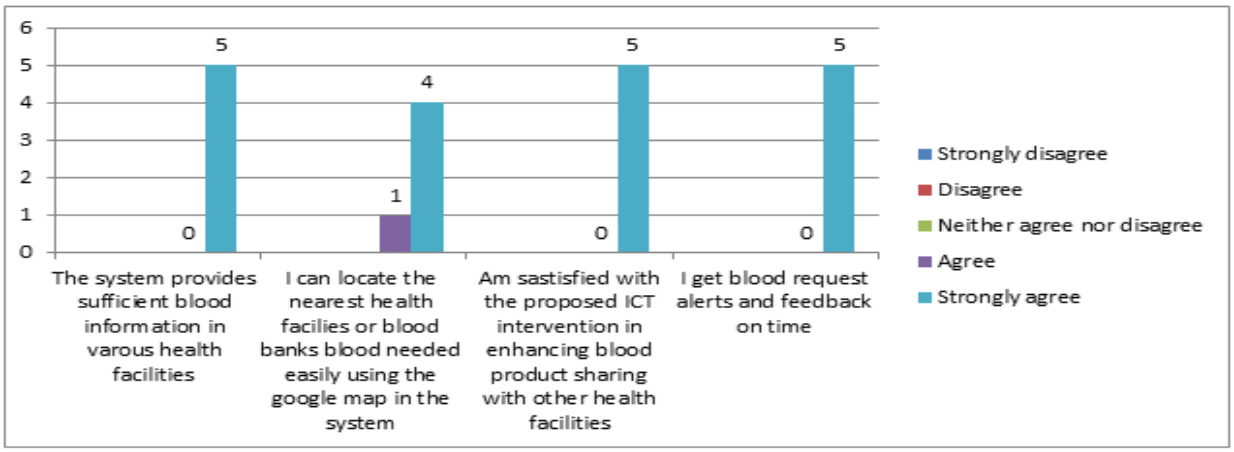
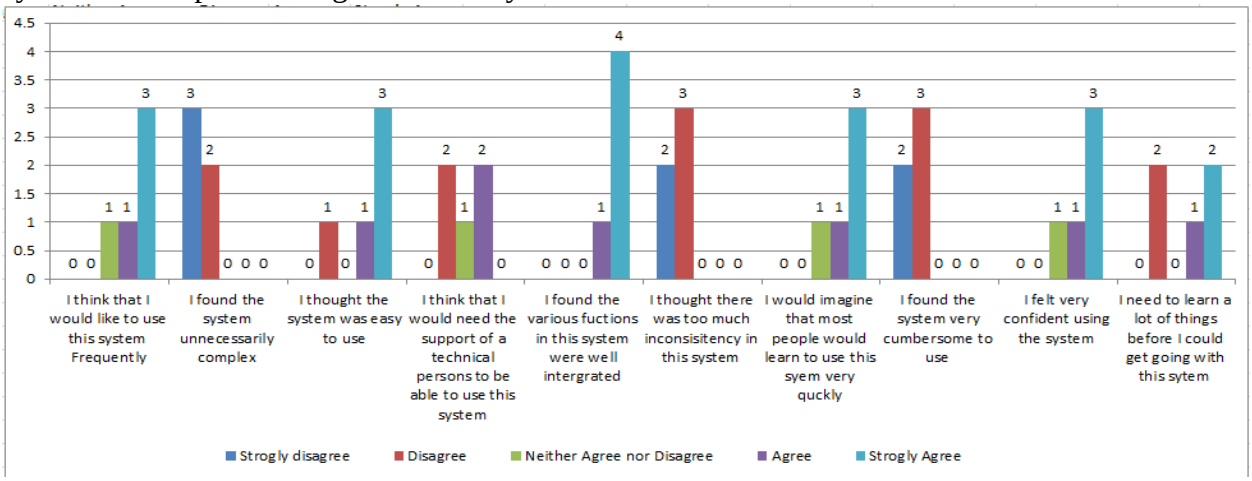


The respondents also filled in a System Usability Scale (SUS) which returned a score of 77.5 out of 100. This shows that the system was satisfactory, usable and acceptable. The System Usability Scale is a reliable tool for measuring usability of a system. 4/5 respondents agreed that they would like to use this system frequently.4/5 Greed that they found the system easy to use. On whether the system was easily learnable, majority of the respondents 3/5 respondents agreed that was easy to learn about the system.



Conclusion

Blood demand remains to be high and exceeds blood supply since blood is highly needed in every health facility. However it can be concluded that during emergencies health facilities source the blood by requesting it from other health facilities and blood banks. As far as the blood sharing among health facilities is concerned, delay in blood supply and not getting the feedback on time during requisitions are the main challenges since the mechanisms used during blood requisitions are telephone calls and blood requisition forms. This proposed solution can be mitigate this scenario and assure of optimal sharing of blood and blood products

Limitation of the study

Difficulty in getting the respondents was the main challenge of this study since many health facilities did not want to disclose their blood information. In other health facilities those people who are responsible in

requesting the blood are lab technicians while in others, doctors are responsible to request the blood hence difficulty to get real respondents in different facilities.

Recommendations for future work

Respondents involved in the testing of the system suggested that they would like to get alerts and feedbacks of blood requests through phone calls. The use of phone calls alerts will ensure the blood requests will be notified on time thus more convenient during emergencies. Also respondents suggested that GIS should be incorporated in the system to locate areas where many people with a particular blood group are located. Drone technology can be incorporated to the system to transport requested blood to health facilities.

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