Ethno Med, 6(3): 141-147 (2012)
PRINT: ISSN 0972-0073 ONLINE: 2456-6802
DOI: 10.31901/24566772.2012/06.03.01

Effective Blood Distribution in Rural Hospitals through ICT Service Oriented Architecture (SOA) Framework: A Case Study in Rural Hospitals in South Africa

Alfred Coleman[1] and Olabode S. Akinsola[2]

[1]School of Computing, University of South Africa, South Africa
Telephone/ Mobile: +27731370859, E-mail: colema@unisa.ac.za
[2]Tshwane university of Technology, Pretoria, South Africa
Telephone/ Mobile: +27839921881, E-mail: osakinsola@gmail.com

KEYWORDS Rural. Hospital. Service Oriented. Architecture. Blood. Transfusion

ABSTRACT Blood is a vital product in healthcare services as most surgical and emergency activities in hospitals depend on blood transfusion. Blood inventory management in rural hospitals at North West Province of South Africa has become a cause of concern to medical practitioners who need blood supplies to save lives. This study investigated various methods used in blood management at rural hospitals. A case study approach was used. Data was collected using semi-structured open- ended interview questions. The interviews were recorded, transcribed and coded. The findings revealed that blood is ordered according to a strict policy. Blood requisition is sent to hospital administrators who order blood from the South African National Blood Service (SANBS) by telephone, postal services and sometimes traveling to SANBS' offices. Challenges like constant electricity power outages and lack of e-health application software to support e-stock management of blood were revealed. An ICT Service Oriented Architecture (SOA) framework based on the principles of integration of services and interoperability of ICT systems was proposed.

INTRODUCTION

Adequate and timely distribution of blood supply to hospitals has become one of the essential activities in the practice of modern medicine in this century. Safe supplies of blood are needed to save lives because blood is often the only means of survival (Tapko 2006). Providing the medical community with a reliable source of information about storage, transfer and distribution of blood is of paramount importance. The blood must be of right efficacy and adequate quantity to correct any homeostatic defect in the normal physiology of the patient and the blood must be free of infections (Tapko 2006).Therefore bridging the gap between blood supplier and blood user is necessary to optimize every step in the blood supply chain management (Cobain 2004). Constant monitoring of blood supply to hospitals will help not only to achieve greater effectiveness in the management of blood inventories at the blood supply centers but also improve the storage capacity of a hospital's blood bank (Chapman et al. 2004).

Brove and McKay (2009) indicate that an Information and Communication (ICT) system based on Service Oriented Architecture (SOA) design has the potential to promote effective blood supply to local hospitals. SOA approach is based on the concept of service (Lammer and Germany 2008). SOA refers to a design of new applications that involve the incorporation of "services" from existing systems (Neubauer 2007). Erl (2005) further indicates that SOA approach can offer a real potential benefit that can improve organizations including healthcare organizations. Therefore the rationale behind this study, is the use of ICT based on (SOA) in the health environment is to provide high performing healthcare system, where all those engaged in the care of the patient are linked together in a secure and interoperable environment. Institute of Medicine (2001) indicates that the flow of healthcare information thus (patient's blood supply) can be safely, efficiently and timely captured and transferred to other healthcare institution at where it is needed the most. Blood by its nature, is perishability, very precious and vital product in health care services and most surgical and emergency activities in the hospitals depend on it.

The challenges of blood supply to rural hospitals in the North West Province of South Africa, includes poor delivery process which sometimes hamper storage and distribution process in the local hospitals. As a result of this, departments within the local hospitals where blood is managed encounter numerous difficulties in blood management processes. Suppliers of blood from blood centers also find it difficult to allo-

cate blood to a needy hospital in a shortest possible time.

Objective of the Study

This study therefore investigated the methods use in blood management processes (ordering, storage and stock transfer) in these rural hospitals. Based on the findings, an ICT service oriented architecture (SOA) framework to improve blood management processes in rural hospitals in South Africa was proposed.

RELATED WORK

Blood products are necessary in hospitals and may be classified as follows: Whole blood, Red blood cells, Blood plasma and Platelets. Each of these products may be stored in adequate facilities for varying amounts of time, which extends from a few days to a few months/years and the unused portion returned to blood bank (Cohen and Pierskalla 1979). There exists different types of blood, namely A,B,O. ARhesus (Rh) system furthers breaks these types into A+, A-, B+, B-, AB+, AB- , O+ and O- as shown in Table 1.

Table 1: Types of blood

Donor	*Recipient*							
	A+	A-	B+	B-	AB+	AB-	O+	O-
A+	Y				Y			
A-	Y	Y			Y	Y		
B+			Y		Y			
B-			Y	Y	Y	Y		
AB+					Y			
AB-					Y	Y		
O+	Y		Y		Y		Y	
O-	Y	Y	Y	Y	Y	Y	Y	Y

In South Africa, blood type proportions are as follows: O= 46%, A=37%, B=14% and AB= 4% (South African National Blood Service-SANBS 2010). Kendall and Lee (2012) formulated a programming model with regard to blood rotations. Rotations refer to the concept of redistribution of blood to hospital blood banks where it has a greater probability of necessary transfusion. This concept reduces wastage; for example if a unit of blood is reaching expiry and is not required for transfusion in the hosting hospital, it would be wise to transport that unit to another hospital where transfusion is required immediately. In order to do this effectively, the use of ICT based on (SOA) in the health environment will be essential. It will link hospitals requiring a particular blood type as a service to other hospitals where blood is overstocked and have been on the shelf for a long time

Brove and McKay (2009) indicate that the use of ICT can assist with identification of problems linked to blood allocation by providing users with real time analysis and automated decision about blood allocation. ICT in blood allocation, again, can help reduce errors that inexperienced staff make and also help in reducing blood wastage (Catassi and Peterson 2009). As previously indicated, an Information and Communication (ICT) system based on Service Oriented Architecture (SOA) design has an additional potential to promote effective blood distribution in local hospitals. SOA allows organizations the autonomy and flexibility they need to take control of their own Information Technology environments, while still enabling inter-organizational business. Service Oriented Architecture (SOA) is an approach to designing a system that allows for loose coupling, interoperability, and standards-based computing (Papazoglou and Heuvel 2007). The main benefits of the SOA architectural style are:

Domain alignment which is the reuse of common services with standard interfaces that increases business and technology opportunities and reduces cost;

Abstraction which means services are autonomous and accessed through a formal contract, which provides loose coupling and abstraction; and

Discoverability which means services can expose descriptions that allow other applications and services to locate them and automatically determine the interface.

METHODS

The study was carried out at the North West Province of South Africa. Ten community hospitals (Taung, Ganyesa, Revilon, Boemhof, Kerkledrop, Rustenburg, Christiana, Boitumelong Empilisweni and Pudimoe) in the North West Province of South Africa were purposefully selected for this study. These hospitals were selected based on their geographical locations which span across the entire Province and forms part of the government owned heath care institutions in South Africa.

The participants for the study were drawn from the entire population of doctors in the ten hospitals. In describing population Polit and Beck (2008) indicate that, it is the aggregate of cases having a common and designated criterion that is accessible as subjects for a study. A purposive sampling technique was used in recruiting participants from the population of doctors. A doctor from each of these hospitals was selected. The participants were selected because of their professions which was relevant to the study. Ten doctors volunteered to participate in the study.

Data was collected using semi-structured open- ended interviews. The interviewees represented different roles ranging from specialist doctors to general practitioners. The interviewees were asked to tell in their own word the processes involved in obtaining and storing blood form South African National Blood Service-SANBS for their clinical practices in their local hospitals and their satisfaction of the processes. The interview lasted for one hour with each interviewee and was audio-recorded and transcribed by the researcher. Data integrity of the study was checked by another researcher. Transcripts were coded using Wolcott's (1994) methods of case study analysis techniques. After the initial coding, broad categories were identified by searching for patterns in the participants responses. The categories included: Blood Requisition Items, Stock Transfer, Maintenance and Return, Reserve and Unreserved of Stock, Inventory Record,Component Received from Other Hospitals and Doctors Satisfaction.

RESULTS

The results are presented under the categories indicated above.

Blood Requisition Items

The doctors indicated that blood requisition form South African National Blood Service (SANBS) is followed when there is an appropriate medical indication for a transfusion and practitioners must be able to justify all requests for blood products. Doctors warn patients of the potential risks inherent in blood transfusion and obtain documented informed consent. This is done using paper forms. Blood needed from SANBS is also requested by completing a paper form which is approved by the hospital administrator and later transported or posted to SANBS. The doctor must complete a requisition form outlining all the above information plus details of previous medical, obstetric, transfusion history, the diagnosis, reason for transfusion, the number and type of component required, and the date and time when the blood or blood components should be available. This information is sent to the blood bank in the local hospital which will assist the blood bank staff in identifying the recipient and in finding compatible unit. Where there is no stock, the order is sent to (SANBS).This is done through telephones or postal services. Internet connectivity in the hospitals is very slow and not utilized for requisition of blood. One respondent indicated *"The blood bank will return all incomplete or illegible forms and improperly labeled samples".*

Stock Transfer, Maintenance and Return

The average demand of blood in South African rural hospitals per month will be about 100 units or more.Important information and parameters such as availability of blood, cross-matching between donor's and recipient's blood groups and blood transfusion reactions are recorded and collected form the hospitals blood bank. Where there is no stock, the manager at the hospitals blood bank places an order form SANBS as indicated above. Also, the interactions with other blood banks within a hospital or outside and delivery/receipts of blood bags between these banks or hospitals are recorded and maintained. All these transaction are done through the use of paper forms. When blood is kept in a particular hospital longer it becomes old and it is returned to SANBS. This return is accompanied by blood return forms filled and signed by the administrator of the hospitals blood bank.

Reserve and Unreserved Bloodstock

Doctors indicated that inventory is very difficult because of the perishable nature of blood. Blood assigned or crossed matched are kept for a particular patient for a number of days and if not used , are returned to subinventory and later returned to SANBS.At the beginning of each day blood units are issued for transfusion from

either the assigned or the unassigned sub inventories. A quantity of units is crossed- matched for particular patient and kept in the assigned sub inventory making it unavailable to other patients for a number of days. The reaming blood units continue to stay in the unassigned inventory. At the end of each day, untransfused units that have completed the cross match release period are returned to the unassigned inventory. The blood units that have exhausted their shelf life are taken away from the inventory and counted as outdated and returned to SANBS. These activities are done by filling in paper forms. These forms are then kept and sent to SANBS by the hospital administrator.

Inventory Record, Component Received from Other Hospitals and Doctors' Satisfaction

When blood units run out stock in the hospitals it is immediately recorded in the inventory record and new orders are made from SANBS. The new orders are recorded when received from the supplier SANBS.This recording processes are done through paper based. In cases of emergency where there is a car accident where many people over 50 or more are demanding for blood, artificial shortage is created. The hospitals immediately contact nearby hospitals for immediate supply or transfer these patients to these neighboring hospitals. Requesting this immediate blood supply is done through telephone, fax, and Sms.

Doctor expressed their dissatisfaction of the long process of filling in forms for ordering blood and the delays associated with the delivery of the blood units from SANBS.

DISCUSSION

This section discusses the findings from the perspective of blood inventory management.

Blood requisition from the blood bank (SANBS) in the hospitals is under the control of the hospital blood bank administrator. Therefore the average age and volume of blood ordered is also under the control of the administrator. Cohen and Pierskalla (1979) indicate that blood may be stored in adequate facilities for varying amounts of time, which extends from a few days to a few months/years and the unused portion returned to blood bank. The effective ordering and return of blood demands an integrated hospital system to improve the availability and utilization of blood. This is supported by Brove and McKay (2009) who indicate that the use of ICT can support blood utilization of blood by providing users with real time analysis and automated decision making

With reserved and unreserved blood in the hospitals blood bank, an Information and Communication (ICT) service is needed to record and transfer information about the balance between the amount of fresh and old blood allocated to hospitals blood bank and SANBS (Kendall and Lee 2012). Again this will track the old blood allocate to patient and inform the administrators to keep fresh blood for future us. The results from the findings indicated that blood shortages in the hospitals occurred frequently. However, this blood shortage can be prevented by assuring that there is sufficient blood on hand at hospital blood banks through effective monitoring using ICT as a tool.

Inventory recordkeeping can be improved through the usage of ICTintegration of the hospitals in the North West. ICT integrated system will assist in preventing overstocking blood in a single hospital while other hospitals run out of stock (Catassi and Peterson 2009).It will also ensure that there is an ample supply of fresh blood for special surgery (for example, open-heart surgery) in these hospitals.

From the above discussion it is evident that, the implementation of ICT service oriented architecture will improve the blood transfer between hospitals in the same region in the North West Province. The ICT based on SOA will further allow hospitals the autonomy and flexibility they need to take control of their own IT environments, while still enabling inter-hospital business (Neubauer 2007). The system will help monitor the units of blood kept at each hospital and the average age of each unit in hospital blood banks .The ICT based on SOA will further help keep regional operating costs to a reasonable level by avoiding excessive blood stock kept in a single hospital.

The Need for ICT Service Oriented Architecture Framework

Based on these findings the researcher proposes ICT service oriented architecture framework to aid effective blood inventory management in the North West rural hospitals.

The architecture emphasizes the integration of services within local hospitals and avails these services to the web through a provincial e-health services hub. This component incorporates the blood services of the hospitals and transforms them from physical and paper phase to the electronic phase through the service hub. This represents the migration from the physical normal blood and paper services of the hospitals to web-based services. Figure 1 illustrates the ICT service oriented architecture framework

The various components of the architecture and their functionalities are discussed below:

Business Component: The business component performs business tasks, applies business rules, manages business data and exposes services for consumption by business process components.

Service Interface Component: This component exposes the functionality of the business components (Business Logic) and the owned data of the business component (Business Entity) as a set of related services. This involves supporting the service contract that describes the functionality and the data available and the semantics, as well as the information about message formats, access and security restrictions and protocols used.

Provincial E-health Service Hub: This is a uniform service integration architecture of infrastructure services that provides consistent support to business services across a defined ecosystem. The Provincial E-health Service Hub is implemented as a SOA architecture using a web service interface. The first set of tasks of the Provincial E-health Service Hub is to identify (authenticate) the user, and to show the service that the user may use and their status. Furthermore, the Hub must be able to route messages to the back-end services. The second function of the Provincial E-health Service Hub is to orchestrate the process that the user performs. This is extending the capabilities of the hub to expose functionality to the user.

Integration Services: Integration service is one of the functions the Provincial e-Health Service Hub provides. The hub provides a rich set of integration blood services which gives connectivity amongst all the participating healthcare systems and stakeholders. The integration services ensure interoperability between connected health systems and services; provide the required network and applicable protocols, message routing and process orchestration, and finally transaction management. These services are offered in a secure, reliable and highly available architecture environment.

E-health Service: This component incorporates the blood services of the hospitals that have been transformed from physical and paper phase to the electronic phase through the service hub. In this study, the framework includes e-requisition, e-stocking-inventory and e-maintenance of blood services. This represents the migration from the physical normal blood and paper services of the hospitals to web services.

User Interface Component: It provides interaction between the user and the application. The user interface components handle the rendering of data for particular end user devices such as PDAs and mobile phones as well as computer devices such as PCs and terminal devices.

Security: The implementation of e-health solutions in the context of the e-health framework must be done in a secure environment. This means that there should be reliable, secure user identification, authentication and authorization. The issue of security and confidentiality of patient information became evident during the interview and therefore, it is important that such identification measures are put in place. One of the respondents stated that there should be signatures and passwords so that "if something goes wrong we know who did what" .Again it was emphasized by the respondents that patient health information is a sensitive issue and must be password protected.

Communication: This is concerned with the interaction between components across the different layers. In the communication layer, an appropriate transport protocol, such as HTTP for internet communication and TCP for intranet communication are considered for sending messages. All the components of the PEHF communicate through a shared network infrastructure using an agreed service protocol. An HL7 messaging standard has been adopted as the messaging standards for the healthcare sector in South Africa. However, there are plans to move to an XML based standards for messaging requirements. Therefore, the ICT service oriented architecture framework adopts these national messaging standards.

CONCLUSION

Having reviewed the problems of blood inventory management in rural hospitals in the

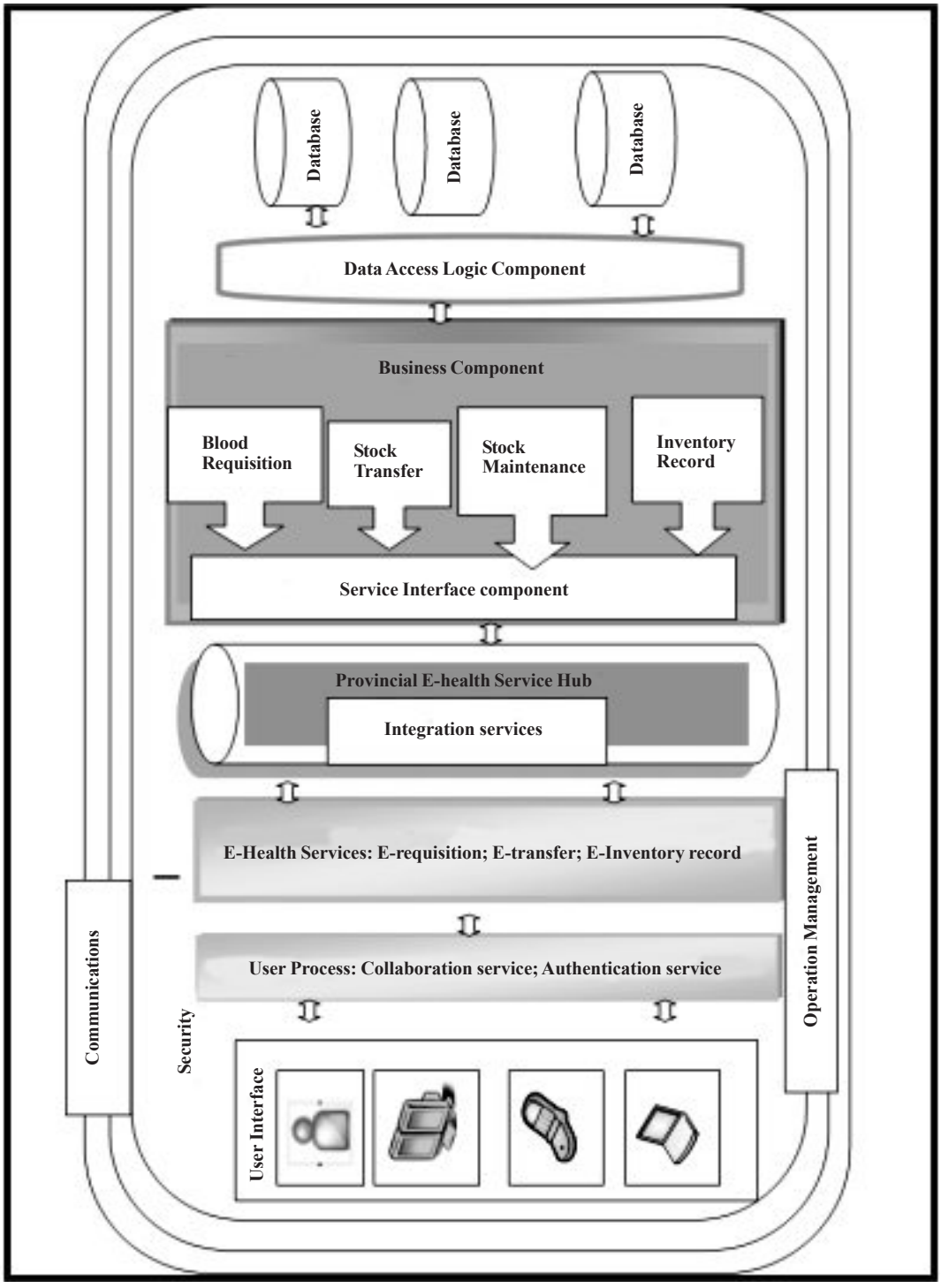

Fig. 1. Service Oriented Architecture (SOA) framework

North West Province, unpacked the concept blood types, blood transfusion' blood requisition issue,bloodstock,transfer, maintenance and stock return, it was noted that blood inventory management is strongly affected by strictcompletion of requisition form, shortages of blood in the hospitals blood bank, lack of ICT integration to facilitate swift transfer and sharing of information, slow Internet connectivity, and constant outages of electricity power supply in rural hospitals. These challenges do not only affect blood inventory management in these hospitals but also prevent the implementation of e-health services like e-requisition, e-transfer, e-inventory record and e-maintenance of blood.

RECOMMENDATIONS

Based on the findings of this paper it is recommended that the proposed ICT Service Oriented Architecture (SOA) framework be implemented on a pilot scale. The pilot implementation should take into account the integration of existing ICT applications in the hospitals, linkage of hospital ICT systems to SANBS systems using HL7 messaging standard, installation of a broader internet bandwidth to improve internet connectivity and speed, and installation of a stand by generator for electricity in rural hospitals during power outages.

REFERENCES

Brove JR, McKay DK 2009. Computer approach to hospital blood bank inventory control. *Transfusion,* 9(3): 143.

Catassi CA, Peterson EL 2009. The blood inventory control system helping blood bank management through computerized inventory control. *Transfusion,* 7(1): 60-69.

Chapman JF, Hyam C, Hick R 2004. Blood inventory management. *VoxSang*, 87: S143–S145.

Cobain TJ 2004. Fresh blood product manufacture, issue, and use: A chain of diminishing returns? *Transfus Med Rev*, 18: 279–292.

Cohen MA, Pierskalla WP 1979. Target inventory levels for a hospital blood bank or a decentralized regional blood banking system. *Transfusion*, 19: 444–454

Erl T 2005. *Service–oriented Architectures*: *Concepts, Technology and Design*. Indiana, USA : Prentice Hall.

Institute of Medicine 2001. *Crossing the Quality Chasm. A New Health System for the 21st Century.* Washington DC: National Academic Press.

Kendall KE, Lee SM 2012. Formulating blood rotation policies with multiple objectives. *Management Science*, 26: 1145-1157.

Lammer A, Germany AG 2008. A procedure model for a SOA-based integration of enterprise system. *International Journal of Enyerprise Information System,* 4 (2).

Neubauer BJ 2007. Introducing SOA and workflow modeling to non-technical students. *J Comput Small Coll*, 22(4): 101-107.

Papazoglou MK, Heuvel WJ 2007. Service oriented architectures: Approaches, technologies and research issues. *The VLDB Journal*, 16(3): 389-415.

Polit DF, Beck CT 2008. *Nursing Research: Generating and Assessing Evidence For Nursing Practice*. Philadelphia: Lippincott Williams and Wilkins.

South African National Blood Service (SANBS) 2010. What's Your Type? South Africa. From <http://www.sanbs.org. za/donors whattype.htm> (Retrieved 10 Aug 2012).

Tapko JB 2006. Status of Blood Safety in the WHO African Region. *Report of the 2006 Survey WHO*. Africa.

Wolcott HF 1994. *Transforming Qualitative Data: Description, Analysis, and Interpretation*. Thousand Oaks, CA: Sage.