System to manage the blood banks stocks: an application in the Brazilian case

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Abstract: The haemotherapic products are produced from blood collected in the campaigns. However, there is a waste of the blood because of lack at the collections' direction. A system was developed to manage the blood collection campaigns. The results shows that the system can model the demand and support the campaigns.

Keywords: haemoterapic products, inventory control, demand forecast

1. INTRODUCTION

The most important challenge for an organization is make available its products at the quantity, at the quality and at the moment that the product is necessary. By the combination of the inventory management and the forecast model, it is possible to optimize the availability of the products (CORRÊA and CORRÊA, 2008).

This is one of the challenges of the blood banks in Brazil. Their objective is to supply the haemoterapics products. This kind of organization must to balance the offer and the demand. They are non-profit organizations connected to the state governments. These organizations must collect the blood, produce the haemotherapics products and distribute then to the hospitals. They work with a perishable product and represent the potential to save lifes. Observing these two characteristics, it is essential the use of the management process to manage the products stocks because the lack of this product may mean the death of people. On the other hand, it is no possible to maintain a high stock because of its perishable nature.

The necessity to supply the demand and low level of blood donations makes the decision makers promote campaigns to collect all type of blood. This attitude creates a high level of stocks of some heamoterapic products and because of this, a high volume of waste. This means it is necessary to use the management techniques to manage the inventory. This kind of control can improve the blood collect campaigns (CARMO and GURGEL, 2014).

The collection of blood occurs through donations. This task is a great daily challenge, because the blood comes from donation and, in Brazil, few people practice this action spontaneously (FUNDAÇÃO PRÓ-SANGUE, 2014). Another constraint to the system is related to the random demand. Therefore, map this behavior said "random" is critical to meet the demand.

Gurgel and Carmo (2014) found in their research that, in addition to the low donation rate, there is still a high rate of blood bags waste, caused by factors such as faults during collection and production process, expiry date, or rejection after quality tests, generating low availability of blood. Observing this problem, this research aims to answer the following question: How can we direct a blood donation campaign in order to maximize the availability of haemotherapic products and minimize the blood bags waste.

This work proposes a system to manage the haemotherapic product inventories in blood banks, in order to control inventory levels for each product and direct the blood donation campaigns. Our system aims to maximize the supply and to minimize the blood waste caused by the expiry date. The system is designed in Java and MySQL database and has been validated using the database of a blood bank from a city in the state of Rio Grande do Norte, Brazil.

This paper is divided into three sections, namely: theoretical framework about the subject studied, the methodology used for system development and system presentation and implementation.

2. THEORETICAL FRAMEWORK

2.1 THE BLOOD BANKS PROBLEMS

The first blood donation experience emerged during the Spanish Civil War, in 1939. With the Second World War, it was necessary the use of the blood banks, transforming this procedure in a medical routine. The blood donation in Europe follows a philosophy to be voluntary and, therefore, is characterized by the scarcity of donors (Fundaçao Hemominas, 2011).

According to Araújo et al. (2011), the shortage of blood is a global problem and affects all countries. Katsaliaki (2008) states that coordinated efforts will be needed to avoid the absence of blood and to avoid situations in which some type of products are wasted and there is the scarcity of others.

In the Brazilian context, at the beginning of the last century, the donation was paid. In 1980 it was created the Blood Program, which regulated the transfusion sector in Brazil, ending the compensation to donors (Fundaçao Hemominas, 2011).

The trend of donations in Brazil is still stationary and only 1.70% of the population can be considered donor, highlighting the failure of inventories (Araújo et al., 2011). According to the Ministry of Health, 1.9% of Brazilians donate blood regularly, fitting to the parameter of 1% to 3% set by the World Health Organization - WHO (Laboissiere, 2011). However, despite Brazil has a reasonable donation rate, it is necessary to direct the blood campaign, because there are different blood types, complicating the balance between offer and demand. There is a blood supply imbalance between different Brazilian regions. This reality extends to other countries.

Gurgel and Carmo (2014) found in their research that, in addition to a low donation rate, there is still a high rate of rejection of blood bags caused by factors such as faults during collection and production, expiry date and rejection after quality tests, generating low availability of blood.

There are problems too related to the production and distribution process, losses related to inventory management and outdated transfusion practices (KATSALIAKI, 2008).

Thus, the use of systems to manage the blood banks inventory is essential, since the inventories must be carefully controlled. Confirming this fact, Presse (2012) states that some products, such as platelets, only last five days, which is why their stocks need to be renewed continuously.

According to Erickson et al (2008), the blood generates several products with different expiry date and variable storage requirements, involving a complex structure of donor recruitment, collection, shipment, separation, testing, distribution and short-term storage.

According to Van Dijk et al. (2009) some experimental studies related to the management of the blood supply were developed, but none presents a structural approach that can be adopted by various blood banks and hospitals. They developed a study of the platelet inventory management. They highlight the importance of studies in the inventory management for blood in Brazil and worldwide. The research presented in this paper aims to fill this gap in the literature.

2.2 THE INFORMATION SYSTEMS

It is essential that organizations implement techniques for effective data management, because the information is strategically important and represent a great value for the organization and can influence the success or failure of an organization (McGee and Prusak, 1994).

Stair and Reynolds (2002) state that the information value for an organization is related to the way it assists the decision makers in achieving organizational goals. In our case, the information is vital to direct the blood campaigns decisions.

A system is defined as a set of interrelated and interdependent parts that form a unit and perform a particular function to achieve a goal (Oliveira, 2009). In this context, the information system is a set of interrelated elements in order to collect, retrieve, process, store and distribute information to support decision making, to control and coordinate the organization (Laudon and Laudon, 2007).

Over the years, the applications of information systems in organizations have been significantly enhanced (O'Brien, 2003). The necessity for these kind of system is because the availability of a large volume of data. These systems allow the creation of the information that managers need to make decisions (Bazzotti and Garcia, 2006).

Laudon and Laudon (2007) argue that the main reason why companies build information systems is the attempt to solve organizational problems and reaction to a change in the environment.

The software built happens through the write instruction in a given programming language. There are several modern languages, each with its peculiarities, among which the most prominent one is the Java language. One of the great challenges of modeling a system is the representation of the calculation routines by using the programming language. In the case of our research, two routines should be modeled: the forecast demand model and the stock level comparison. These two information allow the system to guide the blood campaigns.

3. THE SYSTEM DEVELOPMENT

This study aims to develop a system to manage the blood stocks in order to support decisions associated with the blood campaigns, such as the definition of blood type that should be prioritized in the campaign. The study was conducted following the steps shown in Figure 2, described below.

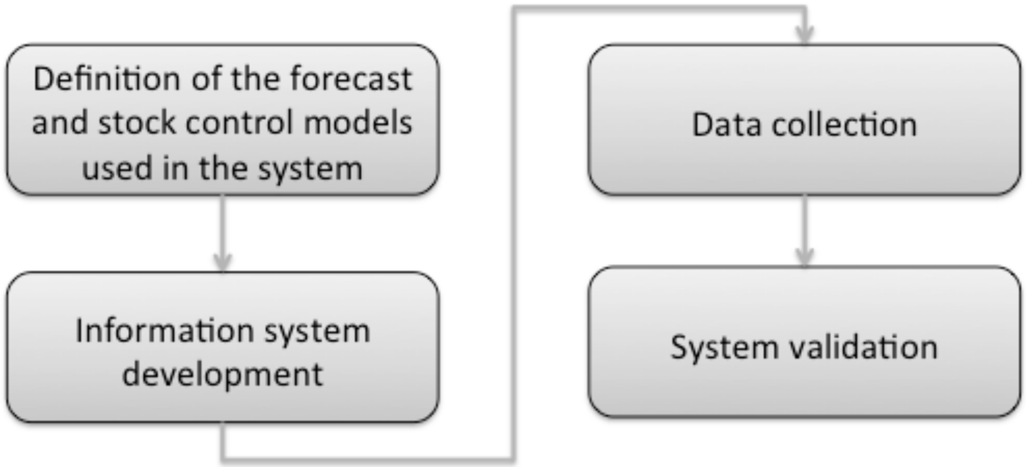


Figure 1 – Steps followed in the development of the system.
Source: Authors.

How we presented at the theoretical framework, there is a lack of development studies of integrated systems for inventory management in blood banks. For the choice of the forecast model, the behavior of historical data was observed. It is possible to conclude the presence of two behaviors: seasonality and trend. The monthly seasonality can be seen through the regular changes year after year. These variations can be explained. In months with festive dates, for example in the carnival period (February or March) and holidays (December), there is an increase in accident rates, causing a greater demand for blood products. Moreover, there has been a growing trend over time, justified by factors such as growth and population increase in the amount of sufferers of diseases that require the use of such products in their treatment - cancer, heart and kidney diseases (Gurgel and Carmo, 2014).

Thus, a method with seasonality and trend proposed by Tubino (2009) was chosen. In our case, the demand forecast model was applied to different blood types, performing demand forecast by product and by blood type. For calculating the forecast, Tubino (2009), lists the following steps:

- Identification of the seasonal cycles;
- Calculation of the average demand for each cycle;
- Calculation of seasonal indices for each demand period;
- Suppression of dataset the seasonality
- Demand forecast calculation through a correlation model;
- Insert the seasonal component to the forecast.

Then, the optimal stock is sized using the sequence of steps defined by Leoprabhu et al. (2010):

- Calculation of the safety stock;
- Calculation of the lead time;

- Calculation of the minimum and maximum stocks level.

The second stage was the programming. It was prioritized the use of the open source software that allow the system portability and gratuity of its development. The option for the Java programming language use is justified because of its inherent characteristics, among them:

- Object Oriented Language, allowing the manipulation of a large number of objects that are interrelated;
- Free technology with IDEs and free servers;
- Portability, enabling its use on different platforms.

The development environment used was the Eclipse IDE, due to its friendly interface. Furthermore, it was chosen the Database Management System (DBMS) MySQL, which has many similar qualities to the Java language, including portability and gratuity technology, modeled and implemented by the MySQL Workbench tool to create of the system database. The information from the personnel involved in production allowed the analysis of functional and non-functional requirements of the organization with respect to the information system.

Then, it was possible to develop the system visual model, using the Astah Professional software. Two diagrams UML (Unified Modeling Language) have been developed in the Java programming: use case diagram and the class diagram. The use case diagram illustrates the features that the system should offer the user and the class diagram enables the visualization of the structure of the classes used in the system and their relationships.

Finally, we designed the relational model. The Entity Relationship Diagram (ERD) presents their attributes and relationships, and is therefore a logical modeling for database.

The Java programming for the demand forecast calculations was based on the model proposed by Ferreira et al. (2012) in his work titled "Proposal for Modeling a System Demand Forecast Java Programming Language".

The next step was the data collection. The database used was the same used by the survey conducted by Gurgel and Carmo (2014). This data reflected only the demand for haemotherapic products in the years 2010 and 2011. For validation purposes, the model was developed to simulate the 2012 year.

To validate the system, the available demand data was collected in the blood bank studied. The system developed was applied to the data set collected and the analysis of the results was performed on the appropriateness of the system functionality in relation to activities undertaken in the blood bank and the achievement of objectives of the work. The name of the system was set to Integrated System for Blood Banks Management (SIGBS).

4. SYSTEM PRESENTATION AND VALIDATION

4.1 SYSTEM PRESENTATION

The SIGBS allows to record and report data and offers, based on inventory levels and demand forecast, the information to the blood campaigns decisions. To start the SIGBS it is necessary to authenticate the user. When the system starts, it checks if the demand forecast data for the current year are registered in the database, since they form the basis for inventory management. After authentication, the user has access to five features:

• Check the stock situation;
• Register entry of products;
• Register products output;
• Register donor;
• Obtain reports.

When it is selected the “Check the stock situation”, it provides to the user the daily need for collection by product and blood type, directing the blood campaigns. The Figure two presents this window.

Figure 2 – Check the stock situation window.

Tipo	Sangue Total	CHPL	CPA	CRIO
A+	8	1	0	1
A-	1	1	1	0
B+	3	1	1	1
B-	0	0	0	0
AB+	2	1	1	0
AB-	0	0	0	0
O+	8	2	1	1
O-	2	1	0	1

The system sets the amount of blood bags to be collected according to the projected stock. For example, a bag of each product Platelet Concentrate (CP), red blood cells (CH), Plasma Fresh (PF) and concentrate Red blood cells Pediatric (CHP) are generated from a Whole Blood bag, requiring only the presentation of the total amount of blood bags to be collected.

The number of bags to be collected is informed by the system for each product / type. The number of bags to be collected was based on the minimum amount of stock in order to avoid unnecessary bags, and hence waste.

In addition, the system displays these values in different colors: red when the blood campaign is necessary and green when the blood campaign is not necessary. For example, in Figure 2, the report indicates that the items in red require a blood campaign, as they are with stock below the minimum stock. For the blood type A +, the blood bank requires 8 blood bags, 1 Concentrate stock RBCs poor in leukocytes, 0 bags Platelet Concentrate Apheresis and 1 cryoprecipitate bag.

4.2 SYSTEM VALIDATION

The main objective of the system is to direct the blood campaigns. It is extremely important to validate the results reported by the system in order to verify that the expected demand is consistent considering the actual demand served by the blood bank.

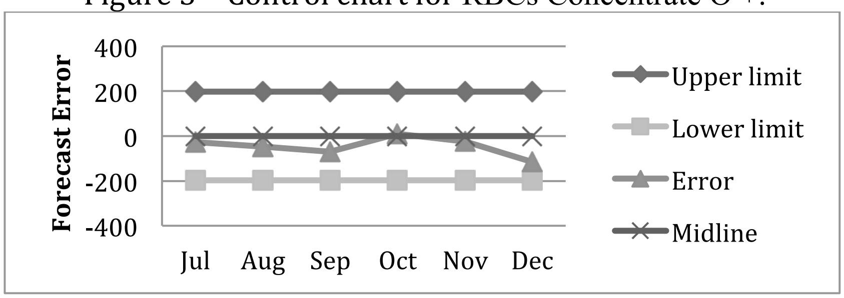
To validate the SIGBS, the 2012 data was collected in a blood bank of the Rio Grande do Norte state, Brazil. These data served as the initial database system. All data is available at the blood book, one book for each half year.

The original intention of this study was to collect the actual demand for the entire year of 2012, however, after three search attempts, it was confirmed that the book of the first half of the year was lost, making it even more evident the need for a tool that provides a more efficient registration of data.

Thus, the system was validated by comparison between actual demand and demand data provided by the system for the months from July to December 2012. According Werkema (1995), "for a process to be predictable is necessary that it is in statistical control. "Through the development of control charts (GC) it is possible to view the variability of demand and to check if the results are on statistical control. From this premise and based on the forecast errors monitoring model proposed by Tubino (2009), this method was used to find the forecast errors.

These values were calculated for each blood type and for each type of product. In Figure 3 it is possible to observe the control chart obtained for the product RBCs Concentrate O +.

Figure 3 – Control chart for RBCs Concentrate O +.



Among the 56 products, only 13 (23% of the total) presented in one of its months an error value that exceeds the established control limits.

Then, it was investigated the reasons of the error. The historical data series in 2010 and 2011 revealed that these products had a pattern of low demand, with random demand peaks. Probably this randomness demand peaks gave the existence of some patients who needed in such months a large amount of specific product.

Quantitative forecasting models could hardly predict randomness of this kind. Considering this aspect and that the percentage of products outside the control limits was 23% of the total, the demand forecast results provided by the SI were considered valid and it is suitable for use as the basis for inventory management of blood products. However, the system informs a parameter to the blood campaign, being necessary to make a critical analysis of the results. Thus it is necessary to consider that the causes that influenced the demand in the past are still valid in the future so that the statements are accepted as true.

Faced with the possible randomness, another factor that justifies the system validation is the fact that this report to the user the need to collect considering that the amount of each type of product to be kept in the blood bank should not be less than the value of Minimum Stock, keeping the system ready for the possible fluctuations in demand.

5. CONCLUSIONS

Due to its social function and a limited number of donors, the bank bloods must minimize the waste. As explained, due to the variety and shorter product life, an inventory management and an efficient blood campaign is important for blood banks fulfill its social function.

However, it is observed not many studies that address this in Brazil. Thus, this research aimed to fill this gap, through the proposition of an information system that manages the blood inventory and the direct blood campaigns.

Through the results presented in this article, the system is an important management tool for blood banks, given its potential to make the demand forecasts and, through comparison with inventory levels, provide a direction of blood collection campaigns.

Although we observed some forecasting errors in specific months, these happen due to randomness, difficult aspect to be incorporated into any forecast model. However, this does not compromise the system validation because the SIGBS was validated for the majority of the tested haemotherapic products. It should be highlighted, however, that for the forecasts be considered valid, it is necessary verify if the causes that influenced the demand in the past continue to influence future demand.

The developed system presents a clear and intuitive interface, with numerous features to support routine activities of blood banks and is able to meet the needs of blood banks in Brazil. However, before applying, it is necessary make an analysis of the data historical series to identify if it has the components seasonality and trend, elements considered in the design of the forecast model.

The next step of this research aims to incorporate to this tool another model to analyze the data historical series and, according to this analysis, to define the forecast model to be used. At this moment, only one forecast model is considered for data that presents the trend and the seasonal components.

A great advantage of this system is the implementation of it in open source development environments using programming languages and database with no financial cost, allowing its applicability on different operating systems.

In addition, the system features were modeled according to the routines of a blood bank, which gives the SIGBS the characteristic of being a dedicated tool for this type of organization, considering the wide variety of products and their complexity.

REFERENCES

Almeida, L. (2014) Bancos de sangue estão com estoques deficientes. Available in the site: < http://atarde.uol.com.br/bahia/salvador/noticias/bancos-de-sangue-estao-com-estoques-deficientes-1597485/>, 2014.

Arujo, F. M. R.; Feliciano, K. V. de O.; Mendes, M. F. de M. Aceitabilidade de doadores de sangue no hemocentro público do Recife, Brasil. Ciência & Saúde Coletiva. 16(12), 2011.

Bazzotti, C. and Garcia, E. A Importância do Sistema de Informação Gerencial na Gestão Empresarial para Tomada de Decisões. Ciências Sociais Aplicadas em Revista. 6(11), 2006.

Correa, H. L. Correa, C. A. Administração de Produção e Operações: manufatura e serviços: uma abordagem estratégica. 2 ed. São Paulo: Atlas, 2008.

Erickson, M. L., Champion, M. H., Klein, R., Ross, R. L., Neal, Z. M. and Snyder, E. L. Management of Blood Shortages In a Tertiary Care Academic Medical Center: The Yale-New Haven Hospital Frozen Blood Reserve. Transfusion. 2252-2263, 2008.

FERREIRA, V. E. S., Paula, M. F. R., Carmo, B. B T. and Almeida, A. C P. Proposta de Modelagem de um Sistema de Previsão de Demanda em Linguagem de Programação Java. In: XXXIII ENEGEP, Encontro Nacional De Engenharia De Produção. Salvador, 2013. Avaliable at the site: < http://www.abepro.org.br/biblioteca/enegep2013_TN_STP_182_040_22848.pdf> Acesso em 20 jan. 2014.

Fundaçao Hemominas Sangue – Breve História. Available at the site: <http://www.hemominas.mg.gov.br/hemominas/menu/cidadao/doacao/breve_historia.html/> Acesso em: 09 jun. 2014.

Fundaçao PRÓ-SANGUE (2014) Institucional: Breve histórico Disponível em: < http://www.prosangue.sp.gov.br/artigos/institucional> Acesso em: 05 jan. 2014.

Gurgel, J. L. M and Carmo, B. B. T. Dimensionamento do Estoque de Derivados de Sangue em um Hemocentro do Brasil Baseado em um Modelo de Gestão de Estoques e Previsão de Demanda. Revista Produção Online. 14(1), 2014.

Katsaliaki, K. Cost-Effective Practices in the Blood Service Sector. Health Policy 86. [online], v. 86, mai. 2008.

Labossière, P. (2011) No Brasil, 1,9% da População Doa Sangue Regularmente. Disponível em: <http://exame.abril.com.br/brasil/noticias/no-brasil-1-9-da-populacao-doa-sangue-regularmente/> Acesso em: 29 jun. 2014.

Laudon, J. P.; Laudon, K. C. Sistemas de informação gerenciais. 7. Ed. São Paulo: Pearson Prentice Hall, 2007.

Mcgee, J. and Prusak, L. Gerenciamento Estratégico da Informação. 14 ed. Rio de Janeiro: Elsevier, 1994.

O'Brien, J. A. Sistemas de Informações: e as Decisões Gerenciais na Era da Internet. 9. ed. São Paulo: Saraiva, 2003

Oliveira, D. P. R. Sistemas, Organização e Métodos: uma Abordagem Gerencial. 18º. Edição, São Paulo: Atlas, 2009.

Presse, F. (2012) OMS Pede Mais Doações no Dia Mundial do Doador de Sangue. Disponível em: <http://g1.globo.com/ciencia-e-saude/noticia/2012/06/oms-pede-mais-doacoes-no-dia-mundial-do-doador-de-sangue.html/> Acesso em: 08 jun. 2014.

Stair, R. M. and Reynolds, G. W. Princípios de Sistemas de Informação: uma Abordagem Gerencial. 4. ed. Rio de Janeiro: LTC, 2002.

Tubino, D. F. Planejamento e Controle da Produção: Teoria e Prática. São Paulo: Atlas, 2009.

Van Dijk, N., Haijema, R., Wal, J. V. D. and Sibinga, C. S. Blood Platelet Production: a Novel Approach for Practical Optimization. Transfusion. 49, 411-420, 2009.

Werkema, M.C.C. Ferramentas estatísticas básicas para o gerenciamento de processos. Belo Horizonte, MG: Fundação Christiano Ottoni, 1995.