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Information system to manage blood inventory and direct collection campaigns

Proposta de um sistema de informação para a gestão de inventário e o direcionamento das campanhas de coleta de sangue

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Abstract: Blood collection is one of the challenges of Brazilian Blood Banks, which aims at providing products produced from blood to hospitals. These organizations face the challenge of meeting supply and demand of blood products. This research paper proposes a system to manage inventory levels of blood products in Blood Banks to direct blood collection campaigns. The idea of the system is to maximize the offer and minimize the waste caused by products' expiry dates. The system was implemented in open source development environment, without financial cost, allowing portability and gratuity characteristics for the system. The system was implemented with real blood bank data to demonstrate system's functionalities, such as demand forecast. Through comparison of this information with inventory levels, the system provides guidance for blood collection campaigns. It presents a clear and intuitive interface with many features to support the activities of the blood banks and it is able to meet the needs of Blood Banks in Brazil and worldwide.

Keywords: Blood banks; Demand forecasting; Inventory management; Java; Database.

Resumo: *Direcionar as campanhas de coleta é um dos desafios dos hemocentros brasileiros, cujo objetivo é fornecer produtos a partir do sangue. Além disso, essas organizações precisam conciliar a oferta e a demanda dos produtos hemoterápicos. Assim, este artigo propõe um sistema para gerenciar os níveis de estoque de produtos nos bancos de sangue e direcionar as campanhas de coleta, de forma a maximizar o atendimento à demanda e minimizar o descarte em função dos prazos de validade dos produtos. O sistema foi implementado em ambiente de desenvolvimento open source, sem custo financeiro, por meio de linguagem de programação e banco de dados que permitam sua utilização em diferentes sistemas operacionais. A partir dos resultados, é possível constatar que o sistema é uma importante ferramenta de gestão para os bancos de sangue, por causa de seu potencial de fazer as previsões de demanda e, por meio da comparação com os níveis de estoque, de fornecer um direcionamento para as campanhas de coleta. O sistema possui uma interface clara e intuitiva com diversas funcionalidades de apoio às atividades rotineiras de hemocentros e é capaz de atendê-los, seja do Brasil, seja do mundo, quanto às suas necessidades.*

Palavras-chave: *Bancos de sangue; Previsão de demanda; Gestão de estoques; Java; Banco de dados.*

1 Introduction

Bloods Banks are responsible for supply products made from blood to hospitals. Different products can be produced by blood, such as red blood cells concentrated, platelets and plasma, among others, each one presenting different expiry dates and specific storage characteristics, making complex the processes of donor identification, blood collection, dispatch, separation, testing, distribution and short-term storage (Erickson et al., 2008). Considering the platelets, the validity date doesn't go beyond five days, according

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to Presse (2012), making necessary renew the stock continually.

However, in order to produce these products, raw material (blood bags) is needed. According to United Nations, even Brazil presenting the higher absolute volume of blood collected in Latin America, the relative volume is smaller than other countries considering its size and population. According to Brazilian Health Ministry, only 1.8% of its population between 16 and 69 years old are considered as blood donors, making clear the need to improve blood donations in order to improve blood products inventory (Barrucho, 2015).

Despite Brazilian blood donation rate being between World Health Organization (WHO) parameters (1 - 3%), acoording to Laboissière (2011), it is necessary provide a guidance for blood collection campaigns in order to avoid blood scarcity and waste due to the variety associated to the products that can be produced from blood bags and blood type, making complex the inventory management process.

Blood scarcity is a worldwide problem. Katsaliaki (2008) argue in favor of coordinated efforts to avoid the scarcity of these products and the waste. The same author observes waste associated to blood inventory management, out-of-date transfusion practices and production and distribution procedures.

We found few scientific papers discussing experimental studies about Blood Bank inventory management (Van Dijk et al., 2009; Sirelson & Brodheim, 1991; Katz et al., 1983; Cohen & Pierskalla, 1975). None of them presents an approach able to be used by different context of blood banks. These researches are focused in specific blood products, generally red blood cells or platelets. Considering their specificities associated to perishability and supply / demand variations, it is necessary establish stock intervals [higher volume, lower volume] for each blood product made from blood bags in order to avoid blood scarcity and waste.

Van Dijk et al. (2009) remark that current scientific researches are focused on simplified inventory management systems, without considering characteristics such as ABO and RH systems, expiry date and the uncertainty associated to supply. Gurgel & Carmo (2014) observed in their research the low blood donation rate and a high level of blood bags waste due to problems during blood collection and processing, expiry date, rejection after quality analysis, generating low blood availability and risk to the live of several patients. They argue in favor of inventory models in order to avoid or reduce the waste associated to expiry date.

As such, the use of an efficient process to manage blood's products inventory is key in order to ensure supply and avoid waste of this type of product, considering that they are perishable and hard to be obtained. Forecast models are able to reduce mistakes when deciding about how much blood to produce / collect, making possible better accuracy of product supply in a perspective of time and quantity needed. Moreover, it reduces a part of uncertainty, allowing decision-makers establish more realistic production plans (Stevenson, 2001). Thus, integrate forecasting and stock management tools allows improving inventory management efficiency.

Gurgel & Carmo (2014) adapted the model developed by Leoprabhu et al. (2010) to Brazilian context, considering the classical inventory management and forecasting models in order to improve stock management process in blood banks. They identified the demand behavior in order to define the most appropriated methods.

According to Slack et al. (2009), inventory control is currently managed through information systems and the results accuracy depends of detailed maintenance of inventory records: inventory registry, demand forecast and inventory level reports. Stair & Reynolds (2002) argue in favor of the value of information for companies, supporting decision-makers when deciding about company's goals achievement. Considering Blood Banks context, data about inventory levels are useful when supporting decisions about blood collection campaigns.

Thus, this research proposes an information system able to manage blood bank inventory, guiding blood collection campaigns in order to maximize blood products availability and to minimize the waste of blood bags associated to expiry date. The system was designed in Java and MySQL database. It was validated considering the data of a Blood Bank of Rio Grande do Norte state, Brazil.

2 System development methodology

This work was realized in order to solve a real problem, being classified as applied research, considering Andrade (2001) definition. The developed system (Integrated system for manage blood banks – SIGBS, in Portuguese) was developed based on Cascade method, defined as a sequence of phases followed linearly (Pressman, 2009). We established the phases based on Unified Process (RUP) elements, a hybrid process combining elements of various software process models, illustrating best practices techniques and supporting the phases of conception, development, and transition of software process (Sommerville, 2011).

The phases of this research are: (i) system initial conception, (ii) forecast and inventory models' choice, (iii) information system development and (iv) system validation through a real case study (system implementation with real blood bank data).

For the first phase, the initial conception was established based on the limits identified in scientific papers. We observed a gap associated to systems able to manage inventory in Blood Banks. The initial conception and the systems basic functions are described by Figure 1

In second phase, we identified adequate models in order to calculate the forecast. This choice was realized based on data collected by the research conducted by Gurgel & Carmo (2014). The forecast model applied was chosen considering demand behavior, being calculated for each product by blood type. For this calculus, we considered the method proposed by Tubino (2009): (i) identification of seasonal cycles; (ii) moving average calculation for each demand cycle; (iii) seasonality indexes for each demand period calculation; (iv) seasonality data set exclusion; (v) demand forecast calculation through linear regression model; (vi) seasonal component reinsertion.

The higher and lower inventory levels were established through the method proposed by Leoprabhu et al. (2010). Their model is based on classical equations, presented by Corrêa & Corrêa (2008) and Wild (2002), as presented at Chart 1.

The system was developed in third phase of our methodology. We used open source software allowing portability and gratuity characteristics for the system. The Java choice is justified because this language presents the following characteristics (Góis, 2009; Quinteiro, 2006; Sopchukm et al., 2014): (i) object-oriented language, allowing the manipulation of a large number of objects that are interrelated; (ii) free technology, with Integrated Development Environment (IDE) and free servers and (iii) portability, allowing its use in different platforms.

The IDE used was Eclipse, considering its friendly development interface. We used MySQL database to manage the database because it presents most of its characteristics as the same as Java language: portability and gratuity of the technology, being modeled and implemented through MySQL Workbench tool for system database creation.

The system requisites were defined based on the need of a Blood Bank located in Rio Grande do Norte state, Brazil. The information provided by employees and the procedure used by them to registry data allowed the analysis of the functional requisites for SIGBS. The requisites were obtained by elicitation, modeling and process analysis, making

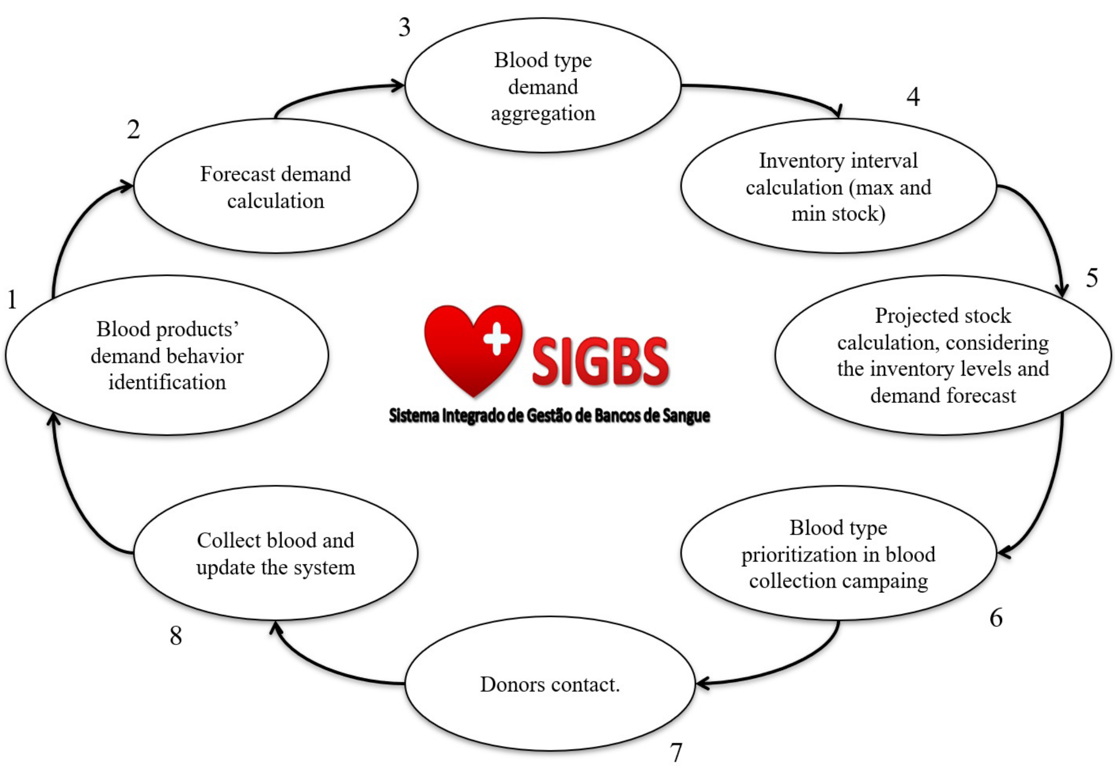

Figure 1. System conception.

Chart 1. Steps to establish the minimum and maximum stocks levels and respective quantity of blood bags to be collected.

Higher and lower inventory levels calculation phase	Equation
1. Average demand	$d_{méd} = \frac{\sum_{i=1}^{n} d_i}{n}$
2. Standard deviation	$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (d_i - d_{méd})^2}{n-1}}$
3. Security stock (Level service = 99,99%)	$Eseg = FS \times \sigma \times \sqrt{\frac{LT}{PP}}$
4. Monthly lower stock level	$Min_{monthly} = D_{máx} \times LT_{máx} + Eseg$
5. Daily lower stock level	$Min_{daily} = Min_{monthly} / 30$
6. Stock projected	$EP_i = EA_i - P_i$
7. Blood bags to be collected by product (tow conditions): a) If projected stock is smaller than lower stock level, collect the number of blood bags equal to lower stock level minus projected stock; b) Otherwise, blood bags equal to zero.	$QB_p = \begin{cases} Min_{daily} - EP_i & se\ EP_i < Min_{daily} \\ 0 & \end{cases}$

Legend: $d_{méd}$ = average demand; d_i = demand of period i; n = number of periods; i = period index (i = 1, 2, 3,..., n); σ = standard deviation for future demand; $Eseg$ = security stock; FS = security factor; LT = lead time for supply; PP = Frequency of the standard deviation; $D_{máx}$ = maximum demand; $LT_{máx}$ = maximum processing *lead time*; $Min_{monthly}$ = monthly minimum stock level; Min_{daily} = daily lower stock level; EP_i = project stock for period i; EA_i = current stock for period i; P_i = forecast for period i; QB_p = quantity of blood bags necessary for product p.

clear the client need in terms of software quality (Rocha et al., 2001).

Based on software requisites, we established the model through Unified Modeling Language (UML). It is a standard language object-oriented, illustrating how system works and how system's objects communicate. As such, UML may be used for develop a model, allowing all other developers understand it without ambiguity (Booch et al., 2005). UML combine diagrams in order to obtain different points of view of the system. For this research, we considered the use case diagram (Figure 2) and class diagram (Figure 3). The use case diagram illustrates the functionalities that the system provides for the user and the class diagram shows the class structure used for system conception and their inter-relationships.

A relational model was used in order to represent which tables would be implements at database. The Diagram Entity Relationship (DER) presents the system's tables and their attributes and relationships. As such, it can be considered as the logical model for the database. Figure 4 illustrate the DER of SIGBS's database. It was developed at MySQL Workbench tool.

Based on DER conception diagrams, we developed the Java programing at IDE Eclipse and the database was implemented at MySQL, through MySQL Workbench tool. To calculate the forecast, we considered the Java model developed by Ferreira et al. (2013).

At the fifth phase, we introduced the 2010 and 2011 experimental data collected at the Blood Bank by Gurgel & Carmo (2014) in order to calculate the forecast for 2012. Real data for 2012 was also collected in order to validate the results generated by the system.

In order to realize the validation of the results, we compared the real demand data from July-December/2012 with the results provided by the system. Werkema (1995) understand that a system is predictable if it is statistically controlled. Control graphs are able to show the demand variability and as such, verify if results are controlled or not.

Tubino (2009) consider that the forecast models are able to generate results presenting standard deviation. As such, statistical process control procedure can be used in order to analyze and improve the quality of forecast results. This approach was used to verify the quality of the results provided by SIGBS. The control graph was established based on forecast deviations (difference between real demand and forecast). The higher and the lower limit control parameters were obtained by the Mean Absolut Deviation (MAD), corresponding to three standard deviations (in order to guarantee a level service able to avoid the lack of blood products).

$$MAD = \frac{\sum |D_t - D_p|}{n} \quad (1)$$

Where:

MAD = *Mean Absolut Deviation*

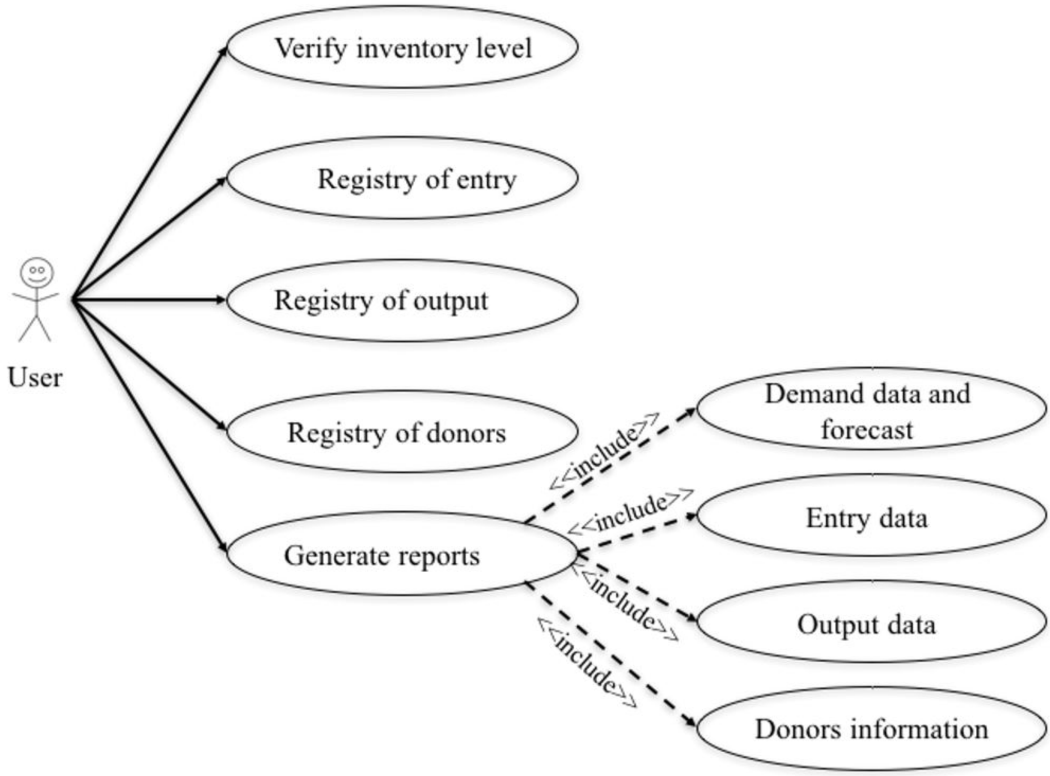

Figure 2. System's use case diagram.

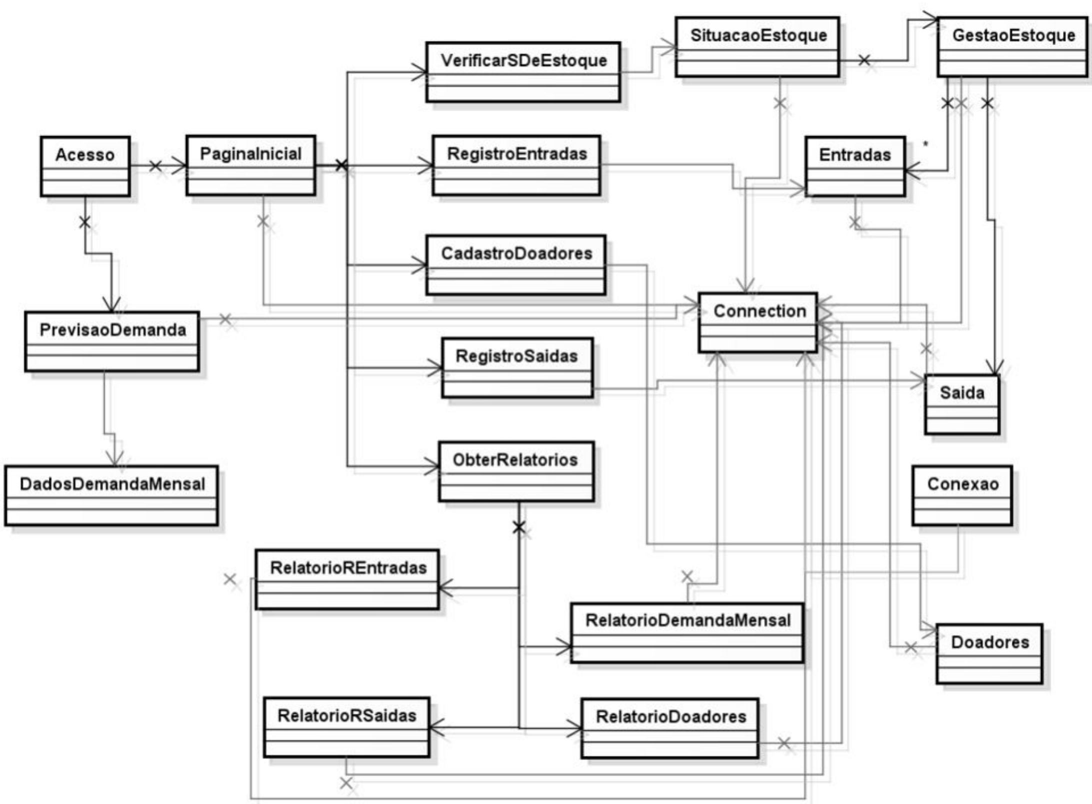

Figure 3. System's class diagram.

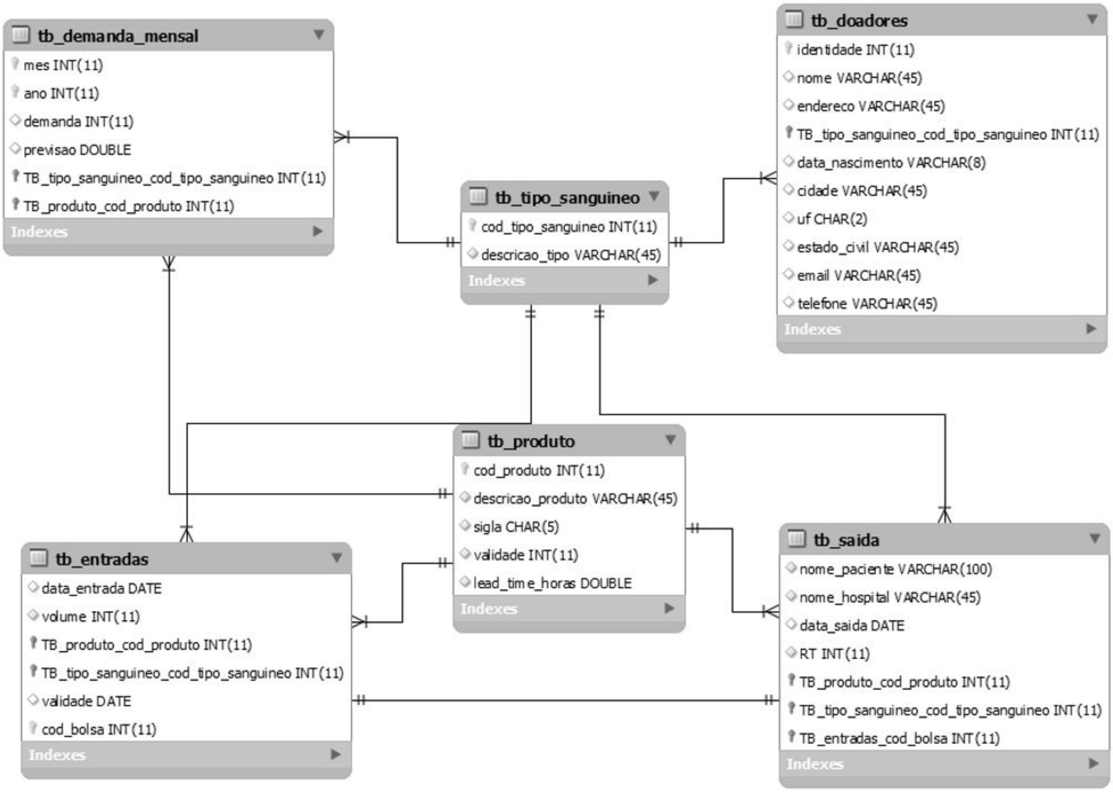

Figure 4. Relationship diagram for system's database.

D_t = Real demand for period t

D_t = Forecast for period t

n = Number of periods

3 System presentation

SIGBS allows obtaining stock levels based on forecast and this information is the base for support blood collection campaigns. Furthermore, it allows the entry of basic data and provides reports presenting information for decision-making processes. This section presents the functionalities of the system.

3.1 System initialization: authentication and main menu

Before start to use SIGBS, the user must be authenticated through a specific login and a respective password in order to access the main menu of the system. When SIGBS is initialized, it verifies if the demand data of current year is available at the system, because this information is the base for the other calculation routines. SIGBS presents five different functions available for users:

- Verify inventory level;
- Registry the input data;
- Registry the output data;
- Registry donor's data
- Generate reports.

3.2 System functionalities

3.2.1 Verify inventory level

When selecting option *"Verificar Situação do Estoque"* (Verify Inventory Level), the screen illustrated by Figure 5 appears for the user. This is the most important functionality of the system, providing for the user the daily demand for blood collection by product and type of blood. This information is obtained through forecast and projected inventory level analysis and it is the support for defining the blood collection campaign.

Considering that some products have different collection and production processes, the system classify the blood bags in four groups: Total Blood, CHPL (Blood Cell Concentrate Poor in Leukocyte), CPA (Platelet Concentrate by Apheresis) and CRIO (Cryoprecipitate). A bag of Platelet Concentrate (CP),

Figure 5. Function: Verify stock level.

Blood Cell (CH) or Fresh Plasma (PF) is produced from a bag of blood collected. Thus, one blood bag is enough to produce these three products. Pediatric red blood cells (CHP) can be also considered as a product obtained from a blood bag because the only difference from CH is the lower volume produced.

CHPL product is obtained through donations realized outside the blood bank. As such, considering that its processing time go beyond the regular blood bag processing time, the other potential products are discarded.

CPA product is different from CP. For this case of donation, only the platelets are obtained. Considering the volume, CPA represents the volume of six blood bags. Finally, CRIO is not produced at the Blood Bank. When this product is need, it is demanded from another Blood Bank.

It is important to remark that one bag of CH A + and two bags of PF A+ can be obtained from only two blood bags. Considering that a bag of CHP differs from CH only in terms of volume, we sum their demand: one bag of CH B+ and another bag of CHP B+ means two blood bags. Thus, the final demand to be collected is established considering the higher value between these three products: CH (CH + CHP), PF and CP.

Moreover, the demand for blood bags to be collected is provided by the system for each type of blood and considering production procedure. This quantity is based on the lower stock level in order to avoid unnecessary blood bag collection, that means avoiding waste.

Besides informing the number of blood bags to be collected, the system presents these results through color legend: collection required (red) and collection not required (green). Considering the example provided by Figure 5, the report indicates that the products in red color need to be produced, meaning that their stock levels are below the lower stock level. Thus, considering blood type A, this Blood Bank needs eight blood bags, one bag of CHPL and one bag of CRIO. This system functionality aims informing the collection need for a specific day (01/20/2012), supporting blood collection campaigns through goals definition for collection and production phases.

3.2.2 Registry the input data

The Registry the input data function allows the user register all the blood products bags that are available (approved by quality tests). When the data is introduced inside the system, it is generated the bag expiry date, calculated from the register entry data and expiry period for the product. For each bag, it is generated a unique code containing the information about the product and the expiry date.

3.2.3 Registry the output data

The Registry the output data function allows the user register all the blood products bags that were used by hospitals. In this case, the user must inform the code of the bag sent to the hospital. This functionality is activated only the bag presents an identification code. If it is not true, the system provides an error message.

3.2.4 Register donor's data

This function allows the user register the donor in order to provide information about the donor when a specific type of blood is need.

3.2.5 Generate reports

Four types of reports can be generated by SIGBS:

- Demand and forecast information: provide reports about the historical demand and the forecast for blood products;
- Blood bags input: provide reports about the number of blood products bags available for use at the system;
- Blood bags output: provide reports about the blood product bags sent by the blood bank for the hospitals;
- Donor's data: provide report about the donors available for donate blood by blood type and the date of last donation.

These reports aim to provide information in order to support blood bank inventory management and guide blood collection campaigns.

4 System validation

The results generated by this system were validated through a comparison of the forecast data with real demand information.

The initial SIGBS database was established based on 2010 and 2011 demand data collected from a Blood Bank of Rio Grande do Norte, Brazil. Currently, all data related to blood products bags are registered at an inventory book. This fact implies a risk of low confidence level, given that the data available at this book risks to be wrong.

At a first moment, we would like to collect data from all 2012 year, but the book where the register the shipping blood products bags was lost. It was available only the book presenting the data form 2nd semester of 2012. This fact reinforces the need of a tools able to guarantee the data integrity.

Figure 6 presents the control graph obtained for CH O+. The errors, considering only the monthly demands from July to December are between control limits.

The results showed that, considering the 56 products, only 13 (23%) presented errors above higher stock level or below the lower stock level. Table 1 provides the products that are outside the established limits control for the months where it is out of control.

Considering the products identified at Table 1 (products outside the stock limits control), we analyzed the reasons for these results. Based on the dataset used for input data to forecast, we remarked that these products presented very low demand, almost zero with some aleatory demands in some periods.

This behavior is probably explained by the aleatory demand related to some hospital's patient that need, in specific months, a high volume of these products. In order to better illustrate the errors results, Table 2 presents the errors and the MADs for a specific product (Fresh Plasma).

Observing Chart 2, the only types of Fresh Plasma where the model is not able to represent the demand (outside MAD limits) are PF B- and PF AB-. Tables 2 and 3 present the demand for these products during the analyzed period (July/December of 2014 and 2015). They show that there are aleatory demands, considering that this fact happens only in

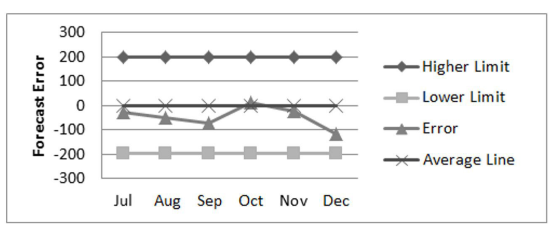

Figure 6. Control graph for CH O + product. Source: Data from case study.

Chart 2. Products presenting results outside the limits control.

Product	Type
PF (Fresh Plasma)	B- (September) e AB- (October)
CP (Platelets Concentrate)	A- (October), B- (September) e AB- (October)
CPA (Platelet Concentrate by Apheresis)	B+ (December) e AB- (October)
CHPL (Blood Cell Concentrate Poor in Leukocyte)	B- (October)
CHP (Pediatric red blood cells)	AB+ (October) e A- (December)
CRIO (Cryoprecipitate)	B+ (August), AB- (October) e O- (October)

Source: Data from case study.

Table 1. Error and MAD parameters for Fresh Plasma product.

Period 2012 (2nd half)	Product	Fresh Plasma (PF)							
	Blood type	A+	B+	AB+	O+	A-	B-	AB-	O-
Monthly Forecast Error	Jul	-35	10	3	43	6	0	0	0
	Ago	23	5	2	53	0	0	0	4
	Sep	-44	2	0	-43	0	10	0	9
	Oct	-22	0	7	-23	1	0	6	15
	Nov	-52	5	0	-30	4	0	1	2
	Dec	-74	5	2	-231	0	0	0	4
Higher limit (4xMAD)		167	18	9,3	282	7	7	4,7	23
Lower limit (-4xMAD)		-167	-18	-9,3	-282	-7	-7	-5	-23

Source: Data from case study.

Table 2. PF B- demand.

Year	Plasma Fresco AB-					
	Monthly demand					
	Jul	Aug	Sept	Oct	Nov	Dec
2010	0	0	0	0	0	0
2011	0	5	0	0	0	0
2012	0	0	0	6	1	0

Table 3. PF AB- demand.

Year	Monthly demand					
	Jul	Aug	Sep	Oct	Nov	Dec
2010	0	0	0	0	0	0
2011	0	5	0	0	0	0
2012	0	0	0	6	1	0

some months for all analyzed period. For example, the demand of Fresh Plasma B- exceeds the higher limit threshold only for September/2012, supporting the hypothesis that such demands have occurred due to the needs of specific patients in certain months. Thus, for these products, it is necessary to maintain a stock level above the lower stock.

Such randomness, without influence on trend, seasonality, or even correlation, could hardly be predicted by quantitative forecasting models, which reinforces a critical analysis of the results need before consider these results in the decision-making process.

We also remark that the system informs a parameter for the collection campaign, through a specific forecasting model. As such, a critical analysis of obtained results is justified. Thus, it is necessary to evaluate if the explanations for these demands remain valid for the future in order to accept the result.

Another element that justifies the system importance is the fact that it informs the user about the demand for each type of product to be stocked by Blood Bank, that should be higher than the lower stock limit, maintaining the system prepared for possible demand variation.

5 Conclusions

Considering the importance of Blood Banks and the limited number of donors, avoid blood bags waste is key in order to guarantee blood products supply. Due to the variety and expiry date of blood products, inventory management system supporting blood collection campaigns is important in order to allow blood banks fulfill their social function.

However, the number of papers addressing this problem is limited. As such, this research proposed a system able to manage blood products inventory and support blood collection campaigns.

Our results show that the developed system is an important management tool to blood banks, considering its ability to calculate blood products' forecast and, by comparing with inventory levels parameters, support blood collection campaigns.

Although there are some forecast errors in specific months, they are explained by aleatory events, an element that is hard to be addressed by forecast models. This limit does not compromise the validation of the system, since SIGBS has been validated for the great majority of blood products tested. However, it is necessary to verify if the reasons that influenced the demand in the past continue to influence the future demand in order to support collection campaigns based on these results. The developed system presents clear and intuitive interface, with several functionalities to support the activities of Blood Banks and it is able to attain the needs of these organizations in Brazil. However, before implement the system, it is necessary collect historical data about past demand in order to design the forecast model.

An advantage of this system is its open source characteristic and programming language implemented, that allows the system being used by different operational systems. Moreover, the system's functionalities were modeled considering the real routines of a Brazilian Blood Bank and its sources of complexity.

The next research step aims integrate to this system a model able to analyze historical demand data in order to make the forecast model independent from an analyst. For this purpose, other forecasting methods would be implemented because only the prediction model for historical series with the seasonal and trend components is considered currently.

It will also be implemented a database with donor's donation data, in order to optimize the collection process and respect the minimum interval between donations from the same donor. A feature to be added in this sense could be, for example, checking the demand for a particular blood type to send e-mail and / or text message to registered donors with such blood type, asking for a donation.

Another future work would be to transform SIGBS into a web tool, in order to make possible registered users access the system any time, in different machines and places, via a web browser (without software installation).

References

Andrade, M. M. (2001). *Introdução à metodologia do trabalho científico*. 5. ed. São Paulo: Atlas.

Barrucho, L. G. (2015). *O que falta para o Brasil doar mais sangue? Dados da ONU apontam que país doa proporcionalmente menos que vizinhos latino-americanos; confira cinco motivos*. Recuperado em 10 de outubro de 2016, de http://g1.globo.com/bemestar/noticia/2015/08/o-que-falta-para-o-brasil-doar-mais-sangue.html

Booch, G., Jacobson, I., Rumbaugh, J. (2005). *UML: guia do usuário*. 2. ed. Rio de Janeiro: Campus.

Cohen, M. A., & Pierskalla, W. P. (1975). Management policies for a regional blood bank. *Transfusion*, 15(1), 58-67. http://dx.doi.org/10.1046/j.1537-2995.1975.15175103512.x. PMid:1114515.

Corrêa, H. L., Corrêa, C. A. (2008). *Administração de produção e operações: manufatura e serviços: uma abordagem estratégica*. 2. ed. São Paulo: Atlas.

Erickson, M. L., Champion, M. H., Klein, R., Ross, R. L., Neal, Z. M., & Snyder, E. L. (2008). Management of blood shortages in a tertiary care academic medical center: the yale-new haven hospital frozen blood reserve. *Transfusion*, 48(10), 2252-2263. http://dx.doi.org/10.1111/j.1537-2995.2008.01816.x. PMid:18631164.

Ferreira, V. E. S., Paula, M. F. R., Carmo, B. B. T., & Almeida, A. C. P. (2013). Proposta de modelagem de um sistema de previsão de demanda em linguagem de programação java. In: *Anais do XXXIII Encontro Nacional de Engenharia de Produção – ENEGEP* (pp. 1-18). Salvador: ABEPRO. Recuperado em 20 jan. 2014, de http://www.abepro.org.br/biblioteca/enegep2013_TN_STP_182_040_22848.pdf

Góis, Y. (2009). *Vantagens e desvantagens JAVA*. Recuperado em 06 de julho de 2014, de http://linksi.blogspot.com.br/2009/07/vantagens-e-desvantagens-java.html

Gurgel, J. L. M., & Carmo, B. B. T. (2014). 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*, 14(1), 264-293. https://doi.org/10.14488/1676-1901.v14.i1.1594.

Katsaliaki, K. (2008). Cost-effective practices in the blood service sector. *Health Policy*, 86(2-3), 276-287. http://dx.doi.org/10.1016/j.healthpol.2007.11.004.

Katz, A. J., Carter, C. W., Saxton, P., Blutt, J., & Kakaiya, R. M. (1983). Simulation analysis of platelets production and inventory management. *Vox Sanguinis*, 44(1), 31-36. http://dx.doi.org/10.1111/j.1423-0410.1983.tb04100.x. PMid:6829180.

Laboissière, P. (2011). *No Brasil, 1,9% da população doa sangue regularmente*. Recuperado em 29 de junho de 2014, de http://exame.abril.com.br/brasil/noticias/no-brasil-1-9-da-populacao-doa-sangue-regularmente

Leoprabhu, E., Prakash, S. S., Vivek, I., Deepan, P., Ranganathan, R. (2010). *Inventory management for blood banks*. Tâmil Nadu: Coimbatore Institute of Tecnology.

Presse, F. (2012). *OMS pede mais doações no dia mundial do doador de sangue*. Recuperado em 08 de junho de 2014, de http://g1.globo.com/ciencia-e-saude/noticia/2012/06/oms-pede-mais-doacoes-no-dia-mundial-do-doador-de-sangue.html/

Pressman, R. S. (2009). *Engenharia de software*. São Paulo: Pearson Makron Books.

Quinteiro, L. (2006). *Vantagens da linguagem java*. Recuperado em 06 de julho de 2014, de http://www.htmlstaff.org/ver.php?id=4384

Rocha, A. R. C., Maldonado, J. C., & Weber, K. C. (2001). *Qualidade de software: teoria e prática* (6. ed.). São Paulo: Prentice Hall.

Sirelson, V., Brodheim, E. (1991). A computer-planning model for blood platelet production and distribution. *Comp Methods Prog Biomed*, 35(4), 279-291. http://dx.doi.org/10.1016/0169-2607(91)90006-F.

Slack, N., Chambers, S., Johnston, R. (2009). *Administração da produção* (3. ed.). São Paulo: Atlas.

Sommerville, I. (2011). *Engenharia de software* (9. ed.). São Paulo: Pearson Prentice Hall.

Sopchukm, A. F., Agner, W. R. F., & Tafuri, L. (2014). Uso da tecnologia java no desenvolvimento de um software para controle de produção. *Revista Científica Semana Acadêmica*, 1(53), Recuperado em 06 de julho de 2014, de https://semanaacademica.org.br/artigo/uso-da-tecnologia-java-no-desenvolvimento-de-um-software-para-controle-de-producao

Stair, R. M., & Reynolds, G. W. (2002). *Princípios de sistemas de informação: uma abordagem gerencial* (4. ed.). Rio de Janeiro: LTC.

Stevenson, W. J. (2001). *Administração das operações de produção* (6. ed.). Rio de Janeiro: LTC.

Tubino, D. F. (2009). *Planejamento e controle da produção: teoria e prática*. São Paulo: Atlas.

Van Dijk, N., Haijema, R., Van Der Wal, J., & Sibinga, C. S. (2009). Blood platelet production: a novel approach for practical optimization. *Transfusion*, 49(3), 411-420. http://dx.doi.org/10.1111/j.1537-2995.2008.01996.x. PMid:19170986.

Werkema, M. C. C. (1995). *Ferramentas estatísticas básicas para o gerenciamento de processos*. Belo Horizonte: Fundação Christiano Ottoni, Escola de Engenharia da UFMG.

Wild, T. (2002). *Best practice in inventory management* (2nd ed.). Woburn: Elsevier Science.