Blood Inventory Management System: Reducing Wastage and Shortage

Breno Barros Telles do Carmo(✉), Daniel Faustino Lacerda de Souza, Paulo Gabriel Gadelha Queiroz, Amim Alleff de Souza, and Itágores Leandro Bezerra de Lira

Universidade Federal Rural do Semi-Árido, Mossoró, RN, Brazil
brenobarros@ufersa.edu.br

Abstract. Blood banks face inventory management problems associated to demand uncertainty and high inventory levels. An efficient blood inventory management is related to the use of simple, transparent and easy-to-understand procedures by blood banks' employees. However, the literature about good practices in blood bank inventory management is scarce, reinforcing new developments need on this subject to ensure a good availability of blood products and reducing wastage. This research presents a blood inventory management system implemented in software, DOAR, able to meet demand while minimizing blood bags wastage. DOAR is simple, user-friendly and able to optimize blood inventory and donations. The purpose of the software is to provide a link between the demand by blood components and collected blood bags.

Keywords: DOAR · Blood banks · Shortage · Wastage · Inventory control

1 Introduction

Blood Banks are responsible for supply products made from blood to hospitals in order to attain patients' needs [1]. As such, [2] define as blood banks' responsibility the guarantee that the donated blood is used efficiently and effectively, minimizing wastage and shortage. Blood scarcity is a worldwide problem. Katsaliaki [3] argue in favor of coordinated efforts in order to reduce wastage associated to blood inventory management practices, out-of-date transfusion practices and production and distribution procedures.

Considering blood supply chains, transfusion occurs through products produced from blood (red blood cells, platelets, fresh plasma among others) presenting different expiry dates depending on the type of product and the form of storage [4]. Thus, [5] classify these products as perishable, making necessary an effective inventory management system in order to reduce disposal while maximizing availability. As such, [1] argue in favor of the use of an efficient process to manage blood's products inventory in order to guarantee blood products' availability and reduce wastage associated to their perishable characteristic.

Perishable products pose challenges in inventory management, such as tradeoff between product availability and waste due to expiry date, temperature out of control,

Z. Anisic et al. (Eds.): IJCIEOM 2019, LNMUINEN, pp. 24–30, 2020.
https://doi.org/10.1007/978-3-030-43616-2_3

problems in refrigeration equipment, among others [6]. As such, blood products shortage and wastage is related to coordination lack between blood bags' supply and blood products' demand. As such, monitoring blood products inventory improves the understanding about blood supply chain, providing balance between supply and demand [7].

The adequate supply of blood bags depends on an effective strategy for collection campaigns. In this sense, management tools can be adapted for health systems reality [8]. Integrated approaches for blood inventory's and donors' management through software is still necessary in order to establish the need for collection and ideal inventory levels [8]. Stanger et al. [6] identified some key elements improving blood inventory management performance: (i) employees training; (ii) ideal stock levels and order sizing; (iii) promote supply chain actors' collaboration; (iv) transparency of the inventory level and; (v) simple inventory procedures.

Blood donors are the raw material source for this supply chain and it is a key element to ensure the system working well [7]. Thus, a policy devoted to donors' management improves the quantity of blood available. Williamson and Devine [4] understand that the use of information and communication technologies (ICTs) can be useful for this purpose.

Another key element is the optimized inventory levels definition in order to balance supply and demand, avoiding scarcity and mitigating the waste of collected material associated with poorly targeted collection campaigns [8].

Stanger et al. [9] have identified key elements that contribute to improve blood inventory management in UK hospitals:

- Human resources and training – training employees to raise awareness of the importance of good inventory management as a key element for a good system performance;
- Define optimized stock levels and order sizes – useful for setting collection targets that can be adjusted continuously;
- Collaboration between departments – promote collaboration between chain links in order to reduce unnecessary requests, improving availability for use and allocation of available blood products;
- Transparency of inventory (transparency and visibility in inventory levels) – inform about inventory levels, since it is a key element to raise the decision-making of chain links on the blood products' quantities to be requested;
- Easy inventory procedures – reduce the complexity and workload for employees, ensuring the optimal supply of products and providing sufficient flexibility so that the blood bank can respond to unexpected changes in demand.

We identified some approaches developed that meet at some level these elements among others [9]. However, all these approaches are limited because they (i) not cover all blood products, (ii) are not implemented in software; (iii) are too complex to be understood by Blood Banks employees and; (iii) does not integrate a functionality that manage blood donors. As such, [6] conclude that it is necessary to develop blood inventory control systems for blood banks able to define blood bags targets to be collected, establish optimal stock levels, being simple and flexible, providing information in a simple and transparent way.

As such, this paper presents an approach implemented in software that, considering the premises proposed by [6] and improving donors' management, is able to meet demand while minimizing the wastage associated to the expiry date.

2 Methods

The development of DOAR followed a user-centred approach, considering the feedback of blood banks employees in order to attend their expectations and provide a simple and flexible solution, respecting their real-life needs. Figure 1 illustrates the methodology used for this development. First stage defines system requirements through an iterative process with stakeholders. Second phase establish and validate the prototype, presenting the main functionalities that will be evaluated by the users. The third stage develops and tests the functionalities. Finally, in the last stage, DOAR was deployed at the blood bank, identifying potential errors and/or improvements.

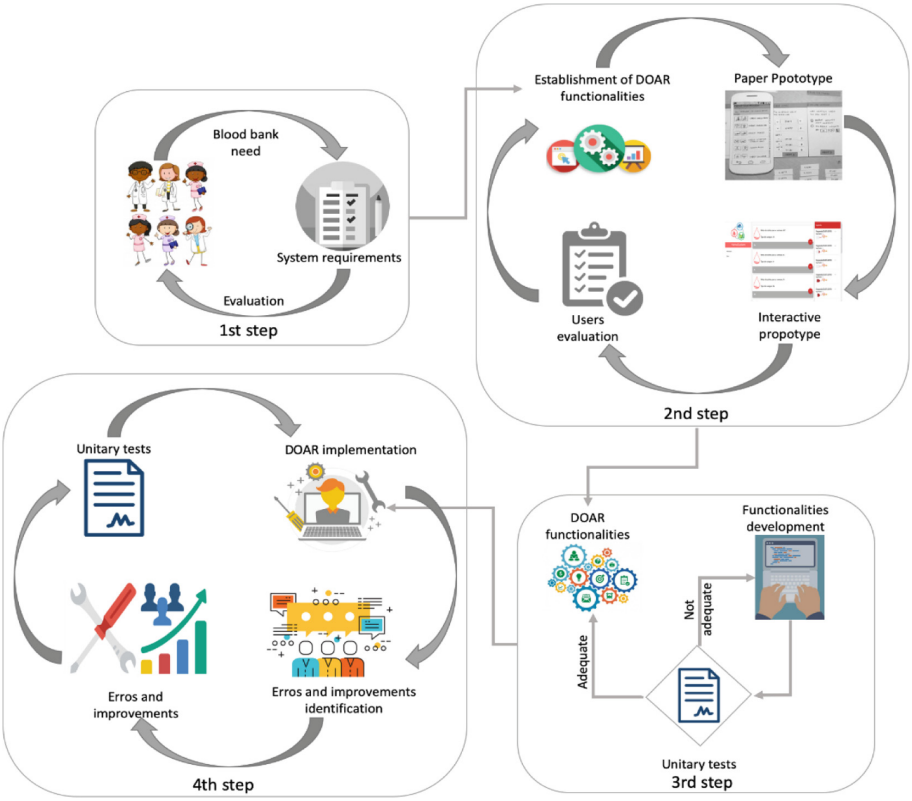

Fig. 1. DOAR development methodology.

On the first step, the iterations with Blood Bank allowed to specify/refine the system requirements, through interactions with users and environment where the system is implemented. Visits and tests with users are essential for discovering new requirements that had not been identified before, which were listed according to the degree of priority. Prototyping was used for this purpose.

The requirements obtained in previous step are expressed in use models and iterative prototypes are proposed to be validated. The requirements validation process is used as a subsidy for the elaboration of interfaces according to the needs of the user and, when validated, it is possible to establish new functionalities, creating new prototypes that must be validated until proceeding to the next stage.

For each use model, an interface is developed in paper, integrated to the interactive prototype and then evaluated by users. The evaluation is performed through the analysis of the user interaction with the prototype. For this purpose, the user is invited to respond questionnaires about the prototype. Considering their point of views, the prototypes are remodelled or integrated a new usage model.

The third step is performed iteratively. In each iteration, some functionalities are chosen to be implemented according to interfaces defined in high fidelity prototype. The features chosen for implementation in the first iteration are those identified as most important by users.

The features are developed according to the priority they were classified by the development team, from highest to lowest. In this way, it is necessary to preserve details such as the number of clicks to access some information and/or the layout of interface elements in relation to the prototype. From this information, it should be checked whether users presenting interacting difficulty with the system interface and whether adjustments must be made to improve man-machine interaction.

Each functionality is tested through a set of unit tests, specified before the development. When detecting errors, the functionality must be corrected by the developer. This step can be performed associated to step 4, in which a new set of usage models are under maintenance.

Finally, on the fourth stage, the system goes through the testing stage. As such, the system is tested in real environment, in order to identify corrections to be done through errors reports by users. The maintenance process is to use deployment feed-back to review or fix functionality.

3 Results

DOAR aims to promote a balance between supply of blood bags and demand for blood components, allowing high availability of blood products with a low wastage rates, resulting in better management of blood bags and their blood components, promoting an optimized use of the products, in order to avoid discards and providing adequate volumes for clinical needs. The conception of the system is illustrated in Fig. 2.

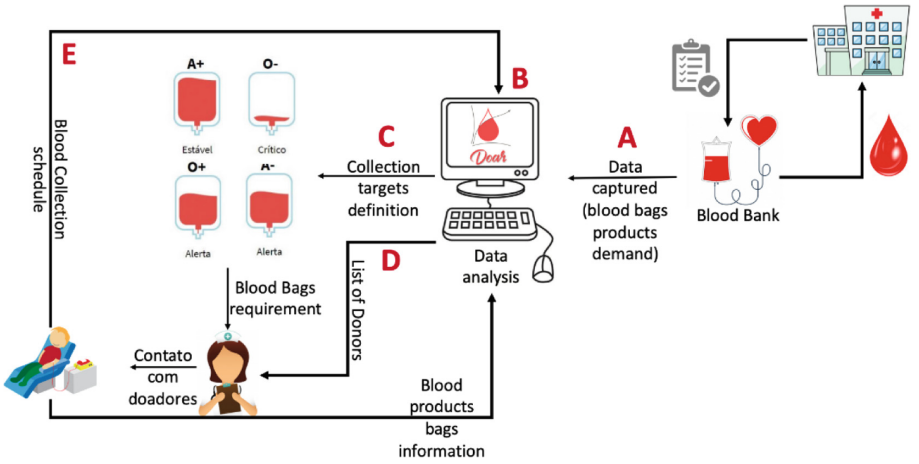

Fig. 2. DOAR conception.

DOAR works as follow:

A. Data collection: DOAR collects blood products bags demand and aggregate them into weekly demands by blood bag type.
B. Analysis of the demand data for projection of optimized levels of stocks (use of statistical models - bootstrap): DOAR determines the ideal stock levels for each blood component for the analysed week through adapted inventory management models, considering each blood product statistical distribution.
C. Blood bags collection targets definition: Considering the inventory management model based on periodic reviews, the weekly collection goal for each blood component is defined by the difference between the desired stock level (established in the previous step) and the current stock.
D. Availability of donor list: Considering the need for collection by blood type, the system lists donors who are eligible for donation.
E. Blood collection schedule: The system provides scheduling feature, allowing blood banks employees to track and track donor schedules by day/time. From this feature, they can track donations that are being made during the week.

In order to exemplify the system developed, Fig. 3 presents DOAR main screen, available when logging in the system. It presents the general collection information of each blood component. In the upper left corner, the collection period is highlighted. It is observed that the collection period refers to the week beginning on 02/17/2019 and ending on 02/23/2019. It is also available the information about each blood component, being presented in their specific fields informing the number of bags needed to be collected during the week. As the collections are carried out, this value is being updated. Another indicator in this field is the drop of blood that presents the performance of the collections in relation to what should be collected and how much has already been collected during that week.

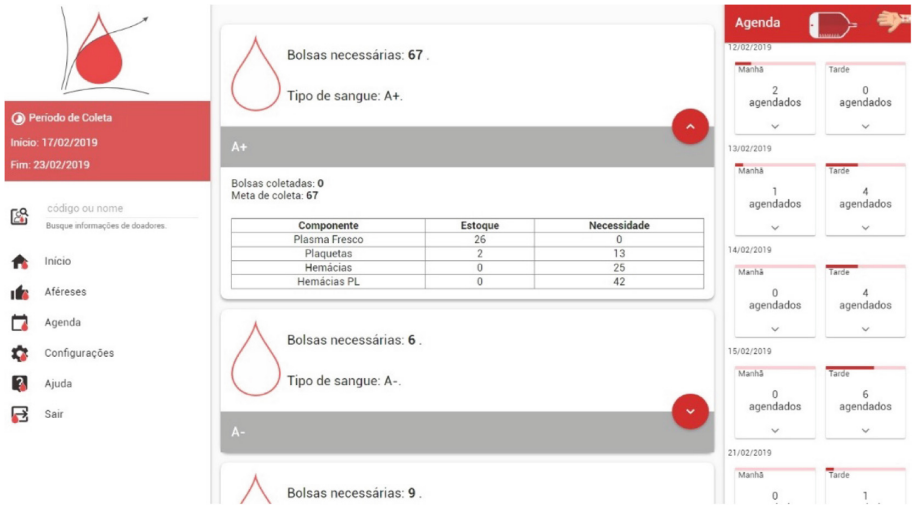

Fig. 3. DOAR main screen.

Other information presented on the main screen refers to scheduled donations by day. In its simplified view, information on how many donors are scheduled per day and per shift are displayed. When you click the scheduled box, the screen expands and displays the names of the scheduled donors.

4 Conclusions

DOAR is a user-friendly system that aims to optimize blood inventory levels and improves donors' management process. The purpose of the software is to provide a link between the demand for blood components and the collected blood bags. It was developed based on the following assumptions:

- Definition of ideal stock levels and order size - use of periodic review model when defining blood bags collection goals, considering the average consumed and service level, which are parameters adjusted continuously and automatically;
- Transparency of the inventory level (transparency and visibility in stock levels) - the system explicitly and clearly indicates the goal of the bags to be collected by blood type, amount already collected and the stock levels of each of the blood components;
- Simple inventory procedures - complexity and reduced workload, making easy the understanding by blood bank staff, avoiding extra activities to employees.

DOAR has a direct interface with Hemovida (system of Brazilian Health Ministry), which simplifies the process, since there is no need for new data. Thus, this software is indicated for the process of management of blood components and donors for blood banks using the Hemovida system. However, it can implanted in a Blood Bank that does not use Hemovida. In this case, an interface must be created for the system used

or, if necessary, a module can be deployed so that the data is entered directly into DOAR, through a database dedicated exclusively to the system.

As future steps, other modules will be developed to be integrated into the DOAR, in order to:

- Integrate automated contact functionality with donors;
- Include the scheduling functionality of blood bags (by day/hour) by hospitals;
- Insert a module to integrate Blood Banks of Rio Grande do Norte state, allowing the exchange of products among the participants of the network;
- Develop a new database in order to DOAR replace Hemovida.

References

1. Chapman, J.F., Hyam, C., Hick, R.: Blood inventory management. Vox Sang. **87**(suppl. 2), S143–S145 (2004)
2. Chapman, J.F.: Unlocking the essentials of effective blood inventory management. Transfusion **47**(s2), 190S–196S (2007)
3. Cheraghi, S., Hosseini-Motlagh, S.-M., Samani, M.R.G.: Integrated planning for blood platelet production: a robust optimization approach. Int. J. Ind. Syst. Eng. **10**(Special issue on healthcare), 55–80 (2017)
4. Ferreira, V.E.S., Carmo, B.B.T., Oliveira, A.G.: Information system to manage blood inventory and direct collection campaigns. Gest. Prod. **26**(2), e2223-1–e2223-11 (2019)
5. Katsaliaki, K.: Cost-effective practices in the blood service sector. Health Policy **86**(3), 276–287 (2008)
6. Lowalekar, H., Ravichandran, N.: Blood bank inventory management in India. Op. Search **51**(3), 376–399 (2013)
7. Williamson, L.M., Devine, D.V.: Challenges in the management of the blood supply. Lancet **381**(9880), 1866–1875 (2013)
8. Perera, G., Hyam, C., Taylor, C., Chapman, J.F.: Hospital blood inventory practice: the factors affecting stock level and wastage. Transfus. Med. **19**(2), 99–104 (2009)
9. Stanger, S.H.W., Wilding, R., Yates, N., Cotton, S.: What drives perishable inventory management performance? Lessons learnt from the UK blood supply chain. Supply Chain Manag. **17**(2), 107–123 (2012)