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Data Blood Management for Algerian Healthcare System : Smart Platform Oriented Approach

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Data Blood Management for Algerian Healthcare System : Smart Platform Oriented Approach

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***Abstract*—Information and computer technology are gaining popularity in blood banks because of their potential to enhance labor productivity and service quality. This article focuses on the significance of web-based technologies in blood bank information management in order to improve the efficacy of this vital, particularly challenging activity in developing nations. Despite the efforts of the World Health Organization and others, blood transfusions and their delivery pose a problem in developing countries: insufficient supply, high demand, and inadequate availability. The research revealed that blood banking institutions in developing countries lacked coordination, as each blood bank maintained its own records that were not shared with other banks. The objective of this paper is to propose a solution that: (1) facilitates coordination between blood banks, health institutions, and donors by interacting with a central database. (2) Providing a solution to one of the most important issues of blood bank information systems, namely, how to effectively use the growing amount of data and information to aid in decision-making. (3) Proposes a decision support system for blood supply management that enables the incorporation of human knowledge into an automated system to improve the efficacy of blood bank management; the objective is to assist health administrators in making the best management decisions that are in line with the best strategies.**

Keywords*—Data blood management, smart blood banks management, blood supply chain, decision support system.

I. Introduction

Blood management is an essential component of global healthcare systems. The blood bank responds to blood requests of all types in cases of blood loss due to accidents, as well as before and during some surgeries, or certain medical conditions affecting the blood or its components [1]. In the United States, more than 15 million units of red blood cells (RBC) are transfused each year, while approximately 108 million units of red blood cells are transfused globally [10], [8]. And, because not all given units are used, the total number of donated units is much larger. However, blood donation is a major concern to the society because blood still a limited resource. Furthermore, people eventually die in some countries due to a lack of blood products or suffer as a result of a lack of access to safe blood transfusions [1], [14]. The blood bank system consists of independent blood centers that collect, store, process, and distribute blood, which is typically collected from unpaid blood donors. Blood is classified into groups (A, B, O, or AB) and according to the Rhesus factor (Rh^{+} or Rh^{-}), and each donor's blood must be carefully matched with the patient who will receive it, as it can transmit infections [17]. In general, there are two methods of donation: whole-blood donation, in which the whole blood is immediately collected in a plastic bag, and apheresis, in which the required blood parts are collected using a mechanical device.

Blood requires special handling and storage procedures, and its shelf life from the donor to usage is short, necessitating system feeding on a regular basis, blood supply chain (BSC) can categorize based on the major stages of blood bag life: collection, production, inventory and distribution, The successful blood donation supply chain is one that achieves meeting the daily demand for blood and following its time pattern. However, due to the massive volume of daily data and information, a variety of errors in the blood donation and transfusion processes are inescapable. The most common stage of error leading to incorrect transfusion is in during the administration of blood or blood components to a patient [20]. Furthermore, prior error in blood collecting, laboratory testing, and, particularly, inventory management of blood components has been identified as a key contributing factor in many of these cases [16].

In healthcare, information, and computer technology has been widely adopted, and it has shown to have considerable potential for enhancing both efficiency and quality. The blood bank system can be used in conjunction with other automated systems. This is in order to simplify and secure most of the donors. Correct documentation of potential reverse screening is one of the most important challenges facing blood banks, so the use of information and computer technology may significantly reduce the incidence of transfusion errors. The US Food and Drug Administration (FDA) issued several directives to assist blood organizations in developing a computer system validation program for blood establishments that is consistent with recognized software validation, quality assurance, and current good software engineering practices. The guideline focuses on the validation of blood computer software [5].

The purpose of this work is to design and then develop a smart blood bank information system for a developing country. The objective to be optimized may allow attracting more donors and providing the corresponding blood type just in time to the patients. The main aim is to bridge the gap between the blood donors and the patients in need for blood, especially in emergency situations, such as accidents, which create an immediate and critical need for specific blood type. As a result, by reducing blood shortage and waste, the system will facilitate the donation process and provide blood to patients in need.

II. Related work

Most articles in literature focus on improving the blood supply chain, and less and less of them are looking in the subject of blood [11]. First, we will discuss some articles that are relevant to the logistics and blood supply chain in both normal and disaster or emergency situations. Many studies have been conducted in the context of the relief supply chain. Baş et al.[7] proposed a framework for scheduling appointments that includes both reserved donors and unreserved donors, with the aim of balancing the production of different blood types between days to offer a very stable feeding to the blood units of the BD system. It includes a Mixed Integer Linear Programming (MILP) model to allocate slots ahead of time based on blood types, and a priority mechanism to allocate spaces ahead of time based on donor requests.

Li et al. [15] proposed a decision integration technique for short-term demand forecasting by incorporating a hybrid demand forecasting model based on statistical time-series modeling, machine learning, and operations research into the construction of a demand decision strategy for RBCs. The results showed that the proposed strategy can reduce inventory level by 40% and order frequency by 60%, which may contribute to reducing shortages and waste due to expiration.

Salazar-Concha and Ramrez-Correa [19] focused on forecasting supply by understanding the intentions of existing donors to make future contributions. The authors concentrated on the forecasting supply under the COVID-19 pandemic's constrained social interaction framework. The results indicate that using seven variables, a decision tree model, and a questionnaire based on the theory of planned behavior, the proposed solution may predict donors' intentions to make additional donations with an accuracy of approximately 87%.

Jabbarzadeh et al. [22] presented a robust optimization model for the blood supply chain during a disaster, which calculates the placement and allocation of facilities while minimizing costs, determine where facilities should be located and how they should be distributed to reduce costs. Dillon et al. [9] developed a two-stage inventory control model, in which decisions regarding the review period and order-up-to-levels are made in the first stage and decisions regarding the daily operation of the system are addressed in the second. In addition, they investigate the distinctions between precise and compatible issuance rules with regards to ABO and RhD compatibility. Hamdan and Diabat have utilized a comparable modeling technique [12].

III. Systems review and example

Several blood bank management systems have been developed in distinct countries.

A. Online Blood Donation Reservation & Management system (Saudi Arabia)

Hashim et al. [13] proposes a management system that allows anyone who wish to give blood to aid the need of blood. The system targets three types of users: blood donors, recipients who need blood, and hospitals that act as intermediaries to manage contact between donors and recipients, the proposed solution enables the user to easily access any information about the blood bank (blood type and blood distribution in different hospitals in Jeddah according to the needs of the hospital). The system helps to improve the operation of the blood bank in terms of reducing human error during the process, making easier the distribution in different hospitals according to the hospital's requirements.

B. BBIS: Blood Bank Information System Based on Cloud Computing (Indonesia)

Ramadhan et al. [18] proposed a system that links personal donors in Indonesia to ensure blood supply. By using a web-based and mobile app with cloud computing, they proposed a way to connect Indonesians who can be personal blood donors. The system makes it easier to find donors, regardless of whether the patient is in an emergency. BBIS offers many donation-management features (requesting blood application, managing data of medical history, donor registration, etc.)

C. BBMS: Blood Bank Management System (Malaysia)

BBMS is a web-based system that helps blood banks manage blood bags. It was designed for Sultanah Nur Zahirah Hospital in Malaysia (HSNZ) [21]. Each bag's blood test results can be entered. Based on Inception, Elaboration, Construction, and Transition, test results indicate whether the blood bag can be delivered to the patient. BBMS provides reports such as blood stock report, donor information, and total blood donation to make blood bank stock more systematic and manageable, the system may also provide information about the donor's blood test results.

D. Blood System in Australia: National Blood Authority (Australia)

The National Blood Authority (NBA) operates several information and communication technology software to ensure a safe blood supply for all Australians: ABDR, BloodPortal, BloodNet, Jurisdictional Reports, MyABDR, and BloodSTAR. Health Provider Engagement offers it 24/7. These software products provide NBA data at various points in the supply chain, including donor management, inventory, emissions, orders, authorization, product output, results, costs, contract performance, and overall NBA performance [3].

IV. Smart Platform for Data blood bank Management

Between 2020 and 2021, 240 blood transfusion facilities collected half million blood bags in Algeria [2]. Nevertheless, there is no central location where all blood bank records can be accessed, even though each bank keeps its own. Demand exceeds capacity at some banks. While expired blood in other banks is wasted, a valuable resource is lost. Blood donor records are also inefficiently managed, as a donor card is issued without any national level record management, i.e., a serial number with no relevance to the blood donation process. There are no synchronized records of blood availability, making blood transfusion difficult because most patients need a blood source if hospitals don't have their type. The majority of patients must obtain blood from family surrogate donors (40% are occasional volunteer donors), a practice considered undesirable by the US Department of Health due to the high incidence of infection [4].

In this section of paper, we propose a Smart Platform for Data Blood Bank Management to address the challenges and problems we mentioned earlier. It includes three sub-systems (Figure.1): Blood Transfusion Management, Blood Transfusion Assessment and Monitoring, and decision support tool for blood supply management.

A. Blood Transfusion Management

Designed for blood transfusion services in hospitals and blood transfusion centers. It is necessary to digitize the blood transfusion processes of collection, production, screening, and distribution. As previously mentioned, the life-threatening nature of blood products necessitates careful management of blood donation and transfusion services. Managing the massive amount of data and information generated by normal blood bank operations in an efficient and effective manner is another significant challenge. Prior to the official blood collection, donors must undergo a series of medical tests and eligibility evaluations. Before the blood can be stored in the inventory, it must pass a series of microbiological and immuno-hematological tests. In fact, all of these practical principles and standards were considered throughout system implementation. In this section of the system, all blood supply data is collected.

B. Blood Transfusion Assessment and Monitoring

A support subsystem for health workers to assessment, and monitoring of the different phases of blood management. The process of collecting and monitoring data has become extremely difficult as the number of blood banks in developing countries keeps on growing. This subsystem proposes to digitize these processes to make them easy and automated (see Figure.**??**). Also, to provide an intuitive and interactive solution for interpreting various statistics, as well as complete statistical reports.

C. Decision support tool for blood supply management

It consists of the following stages: knowledge acquisition, knowledge verification and validation, and knowledge representation. The knowledge can be collected from two resources: blood transfusion guidelines and the adaptive learning module. In the proposed solution, adaptive learning model focus on three specific goals, which are: reduce blood bag wastage, improve blood inventory management using machine learning methods, minimizing blood shortages by predicting blood donor behavior and identifying return donors based on their age and blood group, then suggest an appointment scheduling model to balance the production of blood bags from donation. The new knowledge will be assessed by experts, and his/her input and approval will be used to add it to the validated knowledge base when the knowledge is improved.

V. Results and Discussions

An experimental version of the proposed system has been adopted in one of the main blood donation centers in Algiers in order to evaluate its efficacy.

In this section, we present a variety of graphs and reports gathered during the evaluation period to evaluate the impact of the proposed system on the blood bank supply management stages. The variance between the test year and the previous year is not considered in the comparative analysis of findings, since the COVID-19 pandemic had a substantial impact on the previous year's blood product statistics, [6]. In this study, we propose comparing the findings of 2021, which represents the experimental period, with the five-year average (2016-2020).

A. Blood collection data analysis

In this section, we analyze the total number of blood cells (whole blood and apheresis) collected throughout time. This result is critical for decision makers to identify the number and type of blood bags collected and compare it with blood collected in previous years to estimate the impact of the proposed strategy on the quantity and quality of blood collected. See the following reports, Figures 3-5.

Figure.3 shows the total number of blood bags by donor type: regular, occasional, and voluntary. A regular donor is a donor registered in the database as a periodic donor, signifying he gave more than once in the specified period, mostly, he/she is in good health and is able to donate on a regular basis, occasional donors, who are donors who only donate at awareness events, mostly are collected through mobile blood collection sites (see Figure. 3), and voluntary donors donate for a specific patient or patients, usually family members. The results showed that the proposed strategy increased the collected blood quantity by 11% over the previous five years' average quantities

The highest improvement was in the amount of blood collected from regular donors (Figure.3). This is expected, because the decision support tool was designed to study the behavior of donors based on the data of previous donors, who are often regular donors.

The graph in Figure.4 depicts blood donations by age group for each year. The majority of donors are young (between 18 and 36 years old). Donors aged 18 to 36 years have increased by 7%, while the rest of the age groups have decreased slightly. This is directly related to the quality of the stored data as well as the specific goals during donor scheduling, so that the system proposes appointment scheduling with the goal of increasing the number of donors by reducing appointment cancellations and improving blood quality through targeted smears.

Figure.5 shows blood bag totals by facilities type (fixed and mobile sites). Since the system primarily schedules donation appointments in fixed blood centers based on previous donor data, the graph shows an increase of more than 15% in blood collected at the fixed blood center level, which is directly correlated to improvement goals.

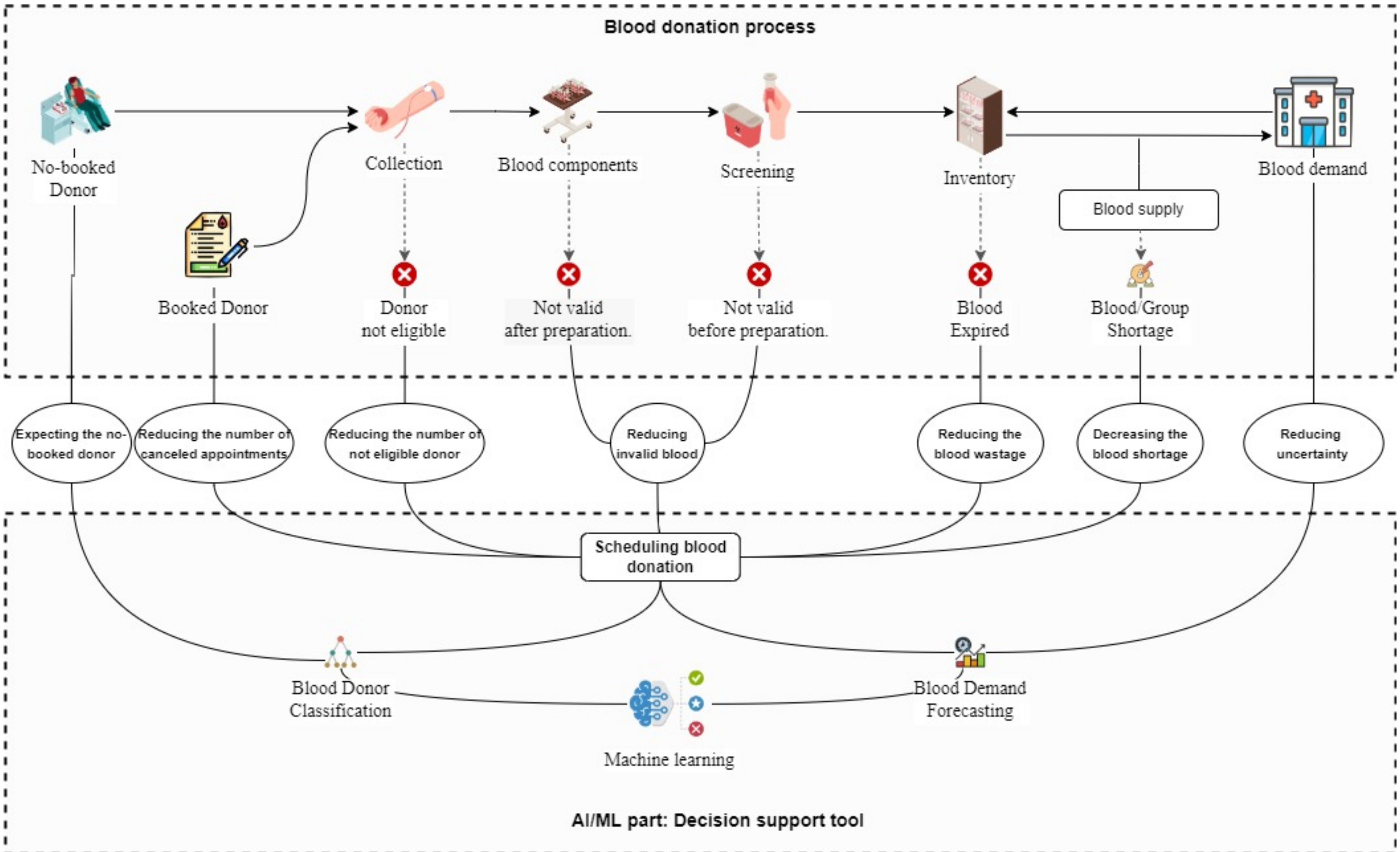

Fig. 1: Flow diagram of the proposed system.

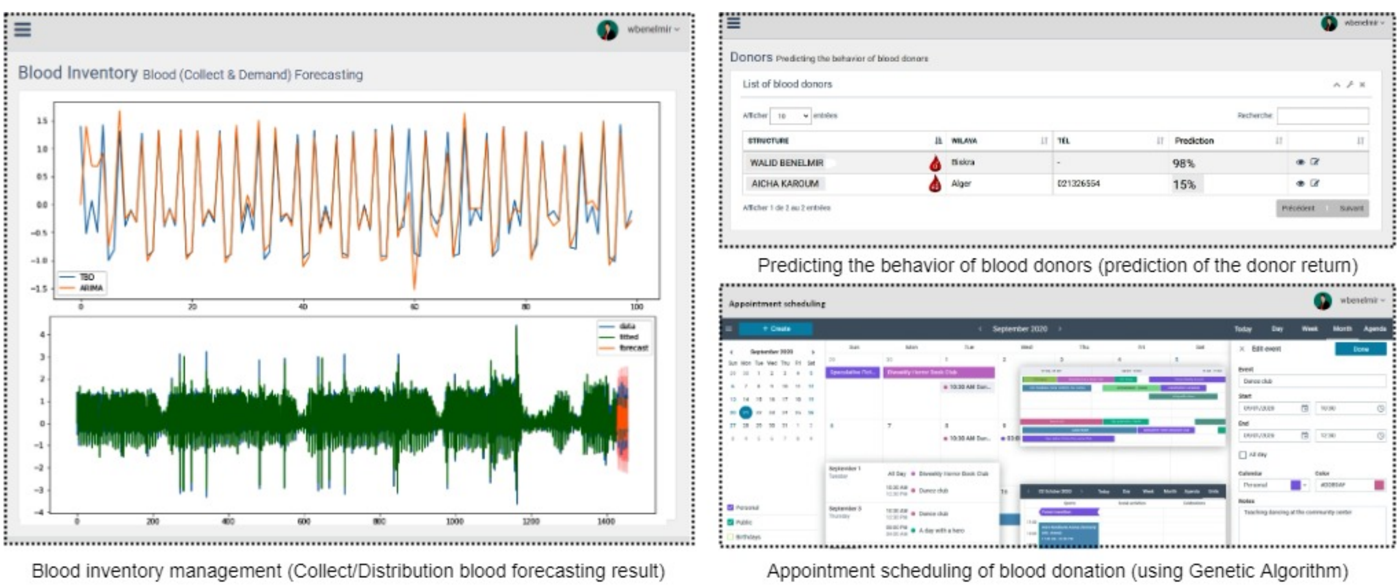

Fig. 2: Overview of the decision support tool for blood supply management.

B. Blood component data analysis

Preparing blood components requires strict health standards, and the quantities of extracted components must meet specific requirements both before and after preparation. Blood components are tested and treated to reduce pathogen transmission during the transfusion.

Figure.6 depicts blood components that didn't meet standards before or after preparation. Any blood donation center must expand donor categories to increase production and quantity. Furthermore, expanded daily donations improve

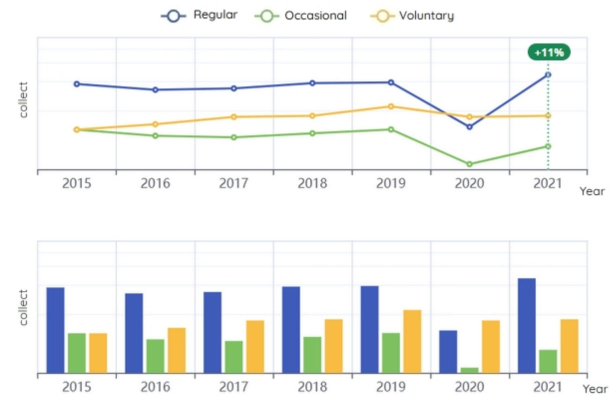

Fig. 3: Blood collect per year (whole blood and apheresis)

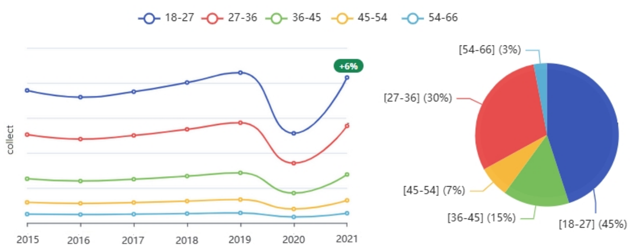

Fig. 4: Number of donations by age group per year.

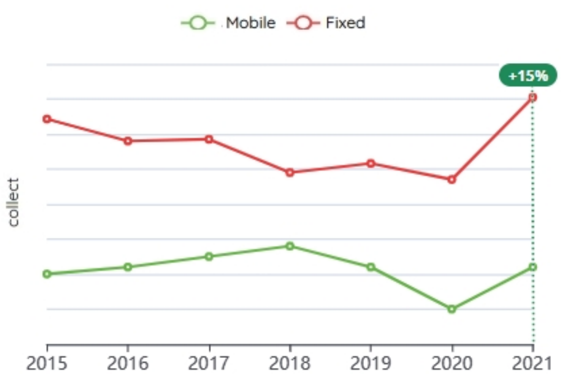

Fig. 5: Mobile and fixed blood collect per year

the database. Increasing the number of regular donors reduced the percentage of unusable blood because there were fewer non-compliant blood components before/after preparation (Figure.6). This improves blood bank management by reducing wastage of blood.

C. Inventory and distribution data analysis

In this section, we present graphical statistics for blood inventory.

The blood transfusion assessment and monitoring module can show the remaining blood stock from the last years, statistics comparing the amount of blood stored with the amount of blood distributed, and the percentage of expired

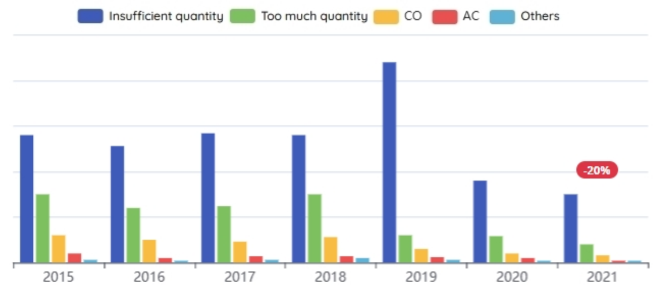

Fig. 6: Non-compliant blood components before/after preparation per year

blood (Figure.7). We notice during the previous years that the higher the percentage of collected blood, the higher the percentage of blood. However, a lower percentage of blood means more blood shortage. Nevertheless, in the proposed system's experimental year, we saw an increase in the quantity and quality of collected blood and a 20% decrease in wasted blood. Unfortunately, we were not able to extract enough information to calculate the percentage of blood wastage.

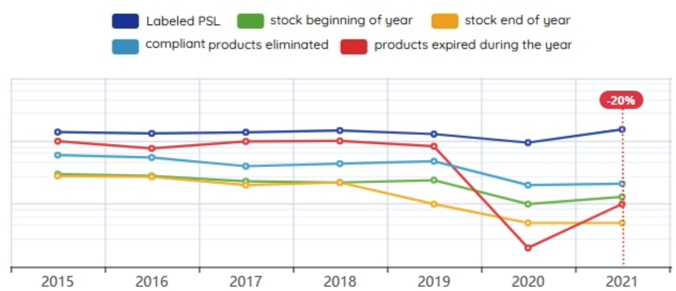

Fig. 7: Blood inventory statistics

VI. Conclusions

This paper proposes to develop a system that interacts with a central database in order to facilitate coordination between blood banks, health institutions, and donors. We also addressed one of the most pressing issues confronting blood bank information systems: the difficulty of coping with ever-increasing amounts of data and information and determining how to utilize it effectively. A decision support system for blood supply management has been proposed to facilitate decision-making as a data-driven, evidence-based process. We tested the system for a year at the blood center in Algiers. The outcomes demonstrated that the proposed solution can improve blood donation management. The blood shortage can be reduced by increasing the quantity of blood collected while decreasing the percentage of blood lost, and by improving the quality of blood bags in stock.

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