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DEVELOPMENT OF AN INFORMATION SYSTEM FOR BLOOD BAG SCREENING AS AN IMPORTANT STEP IN BLOOD TRANSFUSION HANDLING IN INDONESIA

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The implementation of blood bag screening test is very important to identify and prevent transfusion-transmitted diseases such as hepatitis B, hepatitis C, HIV, and syphilis. This paper discusses the development of a blood bag data filtering information system in Indonesia. The object of this research is the management of blood donor and blood bag data.

The results of this study indicate a better operational framework, accurate data management and timely decision-making, related to the safety of blood services. By using modern programming languages such as PHP with the Laravel framework and leveraging the MySQL database, this system integrates blood donor management and screening test results, significantly reducing the risk of disease transmission.

The main feature of this system is its ability to effectively integrate donor data and screening results, which allows real-time access and decision-making. This feature enables the system to solve problems previously identified by conventional methods, significantly reducing the risk of errors and disease transmission. The results of the study indicate that the system can be implemented effectively in the internal environment of blood transfusion units in Indonesia, thereby improving operational services and comprehensive reporting. Hence, proper data and information management will result in better decision-making in the health sector, especially in maintaining high blood safety standards. Thus, this study highlights that the developed information system plays an important and effective role in strengthening blood transfusion management in Indonesia, opening up opportunities for continuous training of health workers

Keywords: donors, blood bags, screening tests, Indonesian Red Cross blood transfusion units

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1. Introduction

At this time, as the world begins to recover from the pandemic that has hit, the need for blood transfusions remains very important for health. Although the pandemic has subsided, the number of patients requiring blood transfusions has not decreased; in fact, it tends to increase throughout the world, including Indonesia. The need for patient blood is not comparable to the amount of blood stock in hospitals. This scarcity of blood stock also occurs in the blood transfusion unit of the Indonesian Red Cross (PMI), so that patients' families have difficulty finding blood to meet the needs of their sick family members [1].

The Indonesian blood transfusion unit has formed a special agency for blood transfusion services at the national level, namely voluntary non-remunerated blood donation (VNRD) [2]. To ensure the safety and quality of donated blood, each blood bag must go through a strict screening process. This test aims to detect infectious diseases such as Hepatitis B, Hepatitis C, HIV, Syphilis and others, which can be transmitted through transfusion [3, 4].

However, the slow access to information regarding the availability of blood bags is a serious problem faced by the PMI blood transfusion unit. This inefficient process not only hinders health workers from responding quickly to blood needs, but also causes anxiety for patients' families who are waiting for certainty. Based on interviews and direct observations conducted by researchers, it was found that management in the blood transfusion unit is still conventional. This results in inefficiencies in the screening process, which is a crucial step to ensure blood safety before distribution. The limitations of the current system can pose risks to patients and reduce public trust. Therefore, a new, more modern and integrated system is needed to overcome problems in the screening process, so that both health workers and patients' families can obtain information about blood bags that are ready to be used efficiently.

2. Literature review and problem statement

The paper [5] introduces an Online Blood Donation System, which offers an accessible, efficient, and secure platform to connect blood donors with those in need. The project includes a comprehensive study, using Agile methodology, HTML, CSS, JavaScript, PHP, and MySQL, to design and develop the system. The objectives of the system include facilitating blood donation, increasing efficiency, enhancing donor participation, ensuring data security, promoting awareness, and improving the overall healthcare system. The project aims to contribute to the healthcare sector by providing innovative solutions to the challenges of blood donation, ultimately saving lives and improving healthcare efficiency. The conclusion of this paper highlights the importance of blood donation in healthcare, the challenges associated with traditional donation methods, and the need for an efficient and effective online system. The chosen methodology, Agile model, and software for implementation are also outlined. The proposed online blood donation system aims to simplify the donation process, increase efficiency, ensure donor security, and contribute to improving the healthcare system. The weakness of this system [5] is that it only provides a platform for donors to register, and for users to search and request blood donors online. Here the admin only manages blood donor activities between donors and recipients. The administrator also only manages the addition of donor data, deletes, updates, and manages pages that display important information about blood donors to the public. Neither admin nor administrator was found to manage blood bags, blood types and medical history. Although the paper mentions scalability and data security as requirements, the implementation details are unclear. The author mentions time constraints due to academic activities and lack of resources that hinder researchers in designing an online blood donor system.

The main objective of the study [6] is to offer a cross-platform web interface that allows anyone to access the contact details of potential blood donors around the required location. The authors developed a backend algorithm to identify potential blood donors. A website was also created using this algorithm employing HTML5, PHP and Java programming languages. XAMPP software was applied to host the local server. The authors proposed an efficient algorithm by considering variables such as frequency of blood donation, last date of donation, gender and age factor. To find eligible donors, the authors have considered all the factors simultaneously, which makes this study unique. Practically this search engine will help automated blood donation organizations and other blood banks to identify potential blood donors from their large database. The drawback of this paper is that the specific algorithm or type of backend algorithm used is not mentioned. There are no technical details regarding the system architecture, technology used, data security, scalability and specific features of the system. The authors emphasize the problem of inefficient blood donor data management in Bangladesh, but there is no discussion on how this system will address other issues related to the blood donation process, such as blood collection logistics, blood group matching and blood distribution to hospitals. The parameters used in the algorithm are address, last blood donation date, blood type, age, frequency of blood donation each year, gender. A history of diseases such as AIDS, hepatitis, drug use is not recorded but is only a recruitment requirement.

In the paper [7] on the hospital management information system in India, it was found that inadequate hardware, slow network or system, inadequate training after confirmation and approval process of observation, lack of data entry operators, differences in the numbering system in blood banks, and many other challenges related to specific departments have become significant obstacles to maximizing the number of patients registered in HMIS (hospital management information system). According to the author, no other teaching case study has been conducted to investigate the implementation of HMIS in a large-scale public healthcare service. This is a mock case study for teaching exercise.

The aim of the study [8] is: the use of Clinical Information Systems (CIS) can reduce healthcare costs over time, improve the quality of medical care and safety, and increase clinical efficiency. However, the implementation of CIS in developing countries poses additional challenges that are different from developed countries. Therefore, this study aims to systematically review the literature, collect and integrate research findings on Success Factors (SFs) in CIS implementation for developing countries. According to the authors, this helps to integrate past knowledge and develop a set of recommendations, presented as a framework, for implementing CIS in developing countries. Materials and Methods used a systematic literature review, followed by qualitative data analysis on published articles related to the requirements and SFs for CIS implementation. In conclusion, the proposed framework can support the implementation of CIS in developing countries while increasing its success rate. Future studies should focus on identifying barriers to CIS implementation in developing countries. Country-specific empirical studies should also be conducted based on the findings of this study to suit the local context.

In the paper [9], writing about the current blood donor shortage in the US, researchers have attempted to identify strategies to attract more young people and to articulate donor needs. The method used a systematic literature review, which can be conducted to investigate mobile applications currently employed to track, attract, and retain donors. Initial results from this pilot study, based on a cross-sectional survey of 952 participants (aged 18 to 39), focus on donor willingness to use mobile applications as a tool to encourage blood donation. Data were collected using a 20-item questionnaire, covering four constructs of the Theory of Planned Behavior to assess respondents' willingness to donate blood. A variety of statistical techniques, including univariate analysis, multivariate analysis, and structural equation modeling, were used to analyze the collected data. In conclusion, many efforts have been made to use mobile applications to make blood donation easier and create a community around blood donation. The results of this study indicate a high level of readiness to use mobile applications for blood donation among the younger generation. The weakness of this study [9] is that the description of the mobile application system is very minimal. It does not explain the features of the application, how the system matches donors with recipients who need blood, the user data security system, and how the donor community is managed in the application. This study only focuses on the willingness of donors to use the application, not on the effectiveness of the application in increasing the number of blood donations in real terms.

The study [10] discusses the development of an Android-based mobile application for blood donor management, which connects hospitals with potential blood donors. The application is designed to address the uncertainty issues in blood donor settings, including ensuring the accuracy of blood requests and donor reliability. The application has several features, including user registration, real-time location tracking, and blood type matching. The comparative analysis of existing application features is not comprehensive enough to justify the development of a new application. The study also lacks details on application testing. Although the application handles sensitive personal information (user and location data), there is minimal discussion on data security aspects. The most under-explored part is the impact and sustainability of the application in the long term. This paper focuses on the application development and features, but does not discuss how the application will be received by hospitals and donors. The study also does not examine system maintenance and updates, nor is there a plan to address future changes in technology or user needs.

In [11], the authors state that there is a growing body of literature showing that computer-assisted interviewing has advantages over face-to-face and written interviews in obtaining sensitive information similar to that sought in blood donor history screening. The paper shows that automated computer-assisted interviewing improves the acquisition of behaviors related to the risk of transfusion-transmitted infections in donors, increases donor and staff satisfaction, and reduces errors and omissions that often accompany traditional interview methods.

The conclusion of this paper is that computerized health history and donor screening improves the accuracy and efficiency of the blood donation process. This translates into transfusion safety, although direct measurement is difficult, given the low rate of donor infection. Enhancements are being developed for the system in this paper, which provide further process improvements consistent with the current emphasis on good manufacturing practices in blood banking and the wider use of electronic health records. Weaknesses of this study include: lack of comprehensive validation, still limited especially with regard to long-term impact and reduction of disease transmission risk. Varied levels of CASI acceptance among donors and staff. Some donors may be reluctant to use the system, while others may feel that it is less personal. Some donors may have difficulty understanding the questions asked in the questionnaire, especially if they have limited reading and comprehension skills.

The paper [12] proposes a web-based intelligent system to manage the blood bank in Zakho District. The system is designed to overcome the challenges in manual blood bank data management, improve efficiency, and predict future blood needs. The system uses MySQL database, PHP programming language, and machine learning technology (LSTM) for blood requirement forecasting. The system also has a user-friendly interface that can be accessed by various users, including super administrators, administrators, donors, and people in need of blood. The paper describes the methodology and algorithms used, but does not provide a comprehensive evaluation of the validity and accuracy of the system. Comprehensive testing, both with simulated data and real data from blood banks, is essential to verify the performance of the system, especially the accuracy of LSTM forecasting. The study does not address the security measures implemented in the system to protect the data from unauthorized access and use. It also does not examine the scalability of the system, i.e. its ability to handle increasing data volumes and larger number of users.

From the above description as a whole, although all of these papers focus on important aspects of blood donor systems and health management, they do not specifically discuss screening tests on blood bags. This may be due to the broader focus of research on data management and system efficiency rather than on the technical details of the blood quality testing process before transfusion.

3. The aim and objectives of the study

The aim of this study is to build an information system for the management of blood screening tests in blood transfusion units in Indonesia. This can speed up blood sample screening activities and reduce the potential risk of infection that could endanger blood recipients.

To achieve this aim, the following objectives are accomplished:

– to record blood donor activities as well as donor data;

– to record blood bag history;

– to provide information on blood availability.

4. Materials and methods

4. 1. Object and hypothesis of the study

The object of this research is the management of blood donor and blood bag data. This system is designed to improve operational efficiency, monitor blood availability in real-time, and integrate donor data with blood screening results. The specifications of the research object are as follows:

1. Donor and blood bag data: this system must be able to record and manage blood donor data accurately, including health history and donor identification.

2. Blood screening process: the system must be able to perform strict blood screening to detect infectious diseases such as hepatitis B, hepatitis C, HIV, and syphilis.

3. Reporting and monitoring: the system must provide real-time information on blood availability and screening results so that health workers can respond quickly to transfusion needs.

The hypothesis of this research focuses on the ability of the developed information system to improve efficiency and safety in blood transfusion management, which is oriented towards: Improving operational efficiency, ensuring transfusion safety and quality monitoring. It is assumed that the data used for the development of the information system is accurate and reliable. Another assumption is that blood transfusion units in Indonesia have access to the technological resources needed to implement the developed information system. This includes adequate hardware, software, and network infrastructure. Another assumption of user support for the successful implementation of the information system is that staff in the blood transfusion unit will receive adequate training and be willing to use the new system. With the simplification adopted in this study, it simplifies the complexity of data management by using structured tables to store information related to blood donors, blood bags, screening results, and blood component separation. In this way, the data management process becomes more efficient and easily accessible. Simplification is also done through the implementation of clear standard screening protocols for detecting infectious diseases. The process is designed to be easy for healthcare workers to follow, minimizing the risk of errors in testing. The system also adopts simplification by integrating data in real-time, allowing quick access to critical information on blood availability and screening results. This improves operational efficiency and decision-making.

This study employs the waterfall model (Fig. 1), representing a systematic and sequential approach to software development.

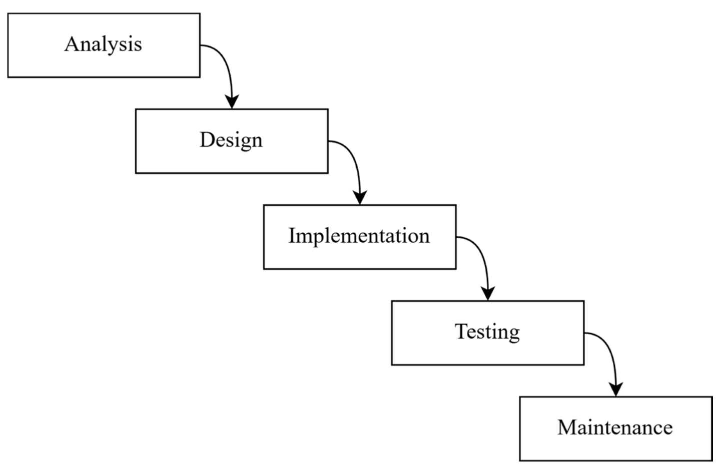

Fig. 1. Waterfall method

To build this screening test management information system, the waterfall model was chosen, because it is one of the software development management models that has clear and easy-to-understand stages [13]. Starting from the requirements, namely determining user needs, then continued with the design stage focusing on creating models identified during the analysis phase. The next is implementation, namely writing code based on the design specifications that have been made, then the testing stage (testing), the results of the implementation are tested to ensure that the system works according to the specified specifications and the last stage is maintenance supported by software that is developed as a whole. To build this system, some data is needed, which is obtained by analyzing the blood bag management system at the Indonesian Red Cross Blood Transfusion Unit.

4. 2. Analysis of the need for blood screening protocols and identification of gaps in the existing system

User needs analysis or requirements analysis, this initial stage begins with the identification of specific end-user needs. This process involves effective communication between developers and stakeholders to determine the requirements that must be met. Requirements include the required features and software needs.

In this study, the author collected information about blood donation through several methods, namely literature study, interviews, and direct observation at the Indonesian Red Cross Blood Transfusion Unit. Literature study was conducted by studying various sources of papers and writings that were used as references to obtain information about the blood donation system. In addition, interviews were conducted with BTU PMI staff regarding the implementation of blood donation and data processing. The author also conducted direct observation by participating as a committee in blood donation activities, so that he could observe the process of the activity directly [14]. Through this combination of methods, the author was able to gain a comprehensive understanding of blood donation management and the challenges faced in its implementation.

The stakeholders define the system requirements in detail, outlining the desired features and functions of the software as follows. The actor requirements in the blood bag screening management system are:

a) Administrator officer: is the actor who manages patient data, donor data, health history data, blood request data, and can view reports;

b) Hemoglobin officer: is the actor who can view donor data, view health history data, manage HB validation data, and can view reports;

c) Doctor is an actor who can view donor data, view health history data, view HB validation data, manage doctor validation data, and view reports;

d) Aftap officer is an actor who can view donor data, view health history data, view HB validation data, view doctor validation data, manage aftap validation data, and view report results;

e) Laboratory officer is an actor who manages screening tests, handles blood components, and reviews reports.

The system is designed using the Unified Modeling Language (UML). UML is the standard modeling language utilized in the industry for the visualization, design, and documentation of systems or software applications. UML defines the standard notation and semantics for the modeling language employed in object-oriented systems. The fundamental components, including structural classification, dynamic behavior, and management strategies, can be understood through many illustrations. UML specifies multiple diagrams, including use case diagrams, class diagrams, entity relationship diagrams, and activity diagrams, among others [15].

In this stage, the system requirements to be developed are described in detail. The management of blood bags in this BTU PMI (Indonesian Red Cross Blood Transfusion Unit) uses a system design with an object-oriented concept, which depicts objects with specific functions that interact with each other.

4. 3. Design of a management information system for tracking and testing

4. 3. 1. Use case of the blood bag management information system

Fig. 2 illustrates the use of the system in a blood transfusion unit, consisting of five actors, namely: Administrator Officer, Hemoglobin Officer, Doctor, Aftap Officer, and Laboratory Officer. Each actor has a specific responsibility in managing the flow of information and ensuring that procedures comply with existing system standards.

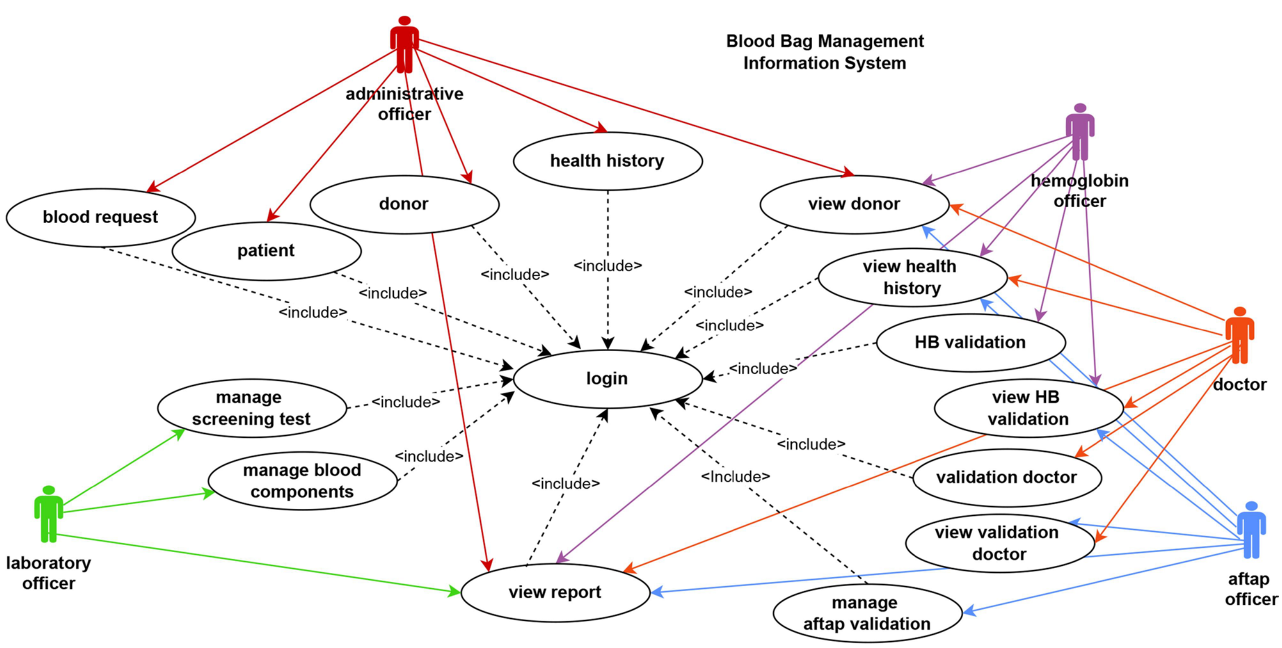

Fig. 2. Use case of the blood bag management information system

Based on the use case diagram in Fig. 2, it can be seen that all five actors can log in. Administrator Officers can perform activities in the system, including managing patient data, managing donor data, managing health history data, and managing blood request data. Hemoglobin Officers can only manage HB validation. Doctors' activities are limited to managing doctor validation data; in addition, they can only view donor data, health history data, HB validation data, and view reports. Aftap Officers only manage aftap validation data, while Laboratory Officers are responsible for managing screening tests and blood component management.

4. 3. 2. Activity diagram managing the blood components system

Activity diagrams describe the workflow of various user or system activities, the individuals who carry out the activities, and the sequential flow of those activities [16]. Based on the designed use case diagram, the system has 28 activities in detail, but here the author only presents 2 activity diagrams, namely the Blood Screening Management Activity Diagram in Fig. 3, and the Blood Component Management Activity Diagram in Fig. 4. Class diagrams are the most commonly used diagrams. They improve communication between team members, providing maintenance engineers with a blueprint of the system to get an overview of how the software is structured before delving into the code [17].

Fig. 3 shows the workflow of a laboratory officer who receives blood bags and samples, then performs a screening test in the laboratory. The screening test results are validated; if the data entered is valid, the system will save the screening test results in the Indonesian Red Cross Blood Transfusion Unit (BTU PMI) database.

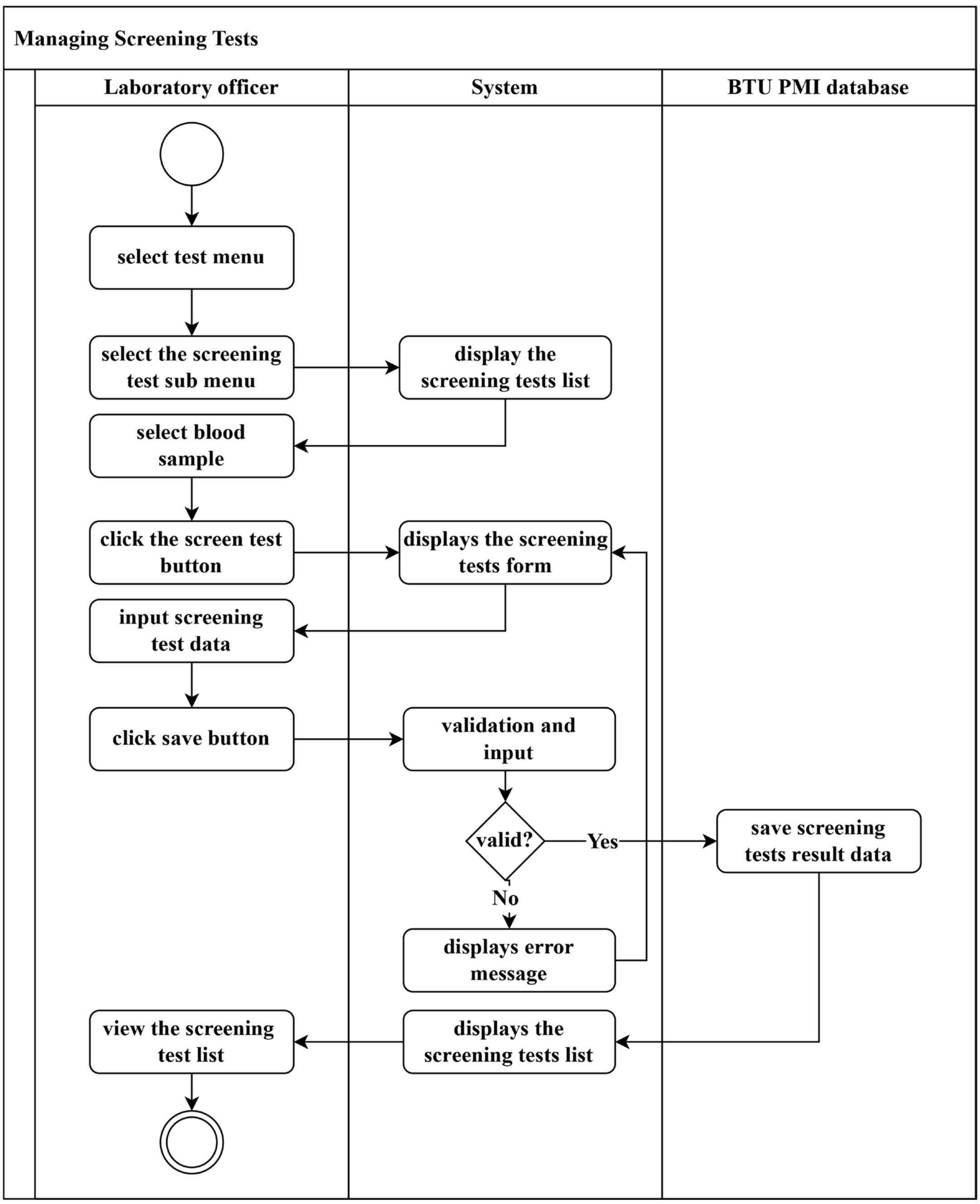

Fig. 3. Activity diagram managing screening tests

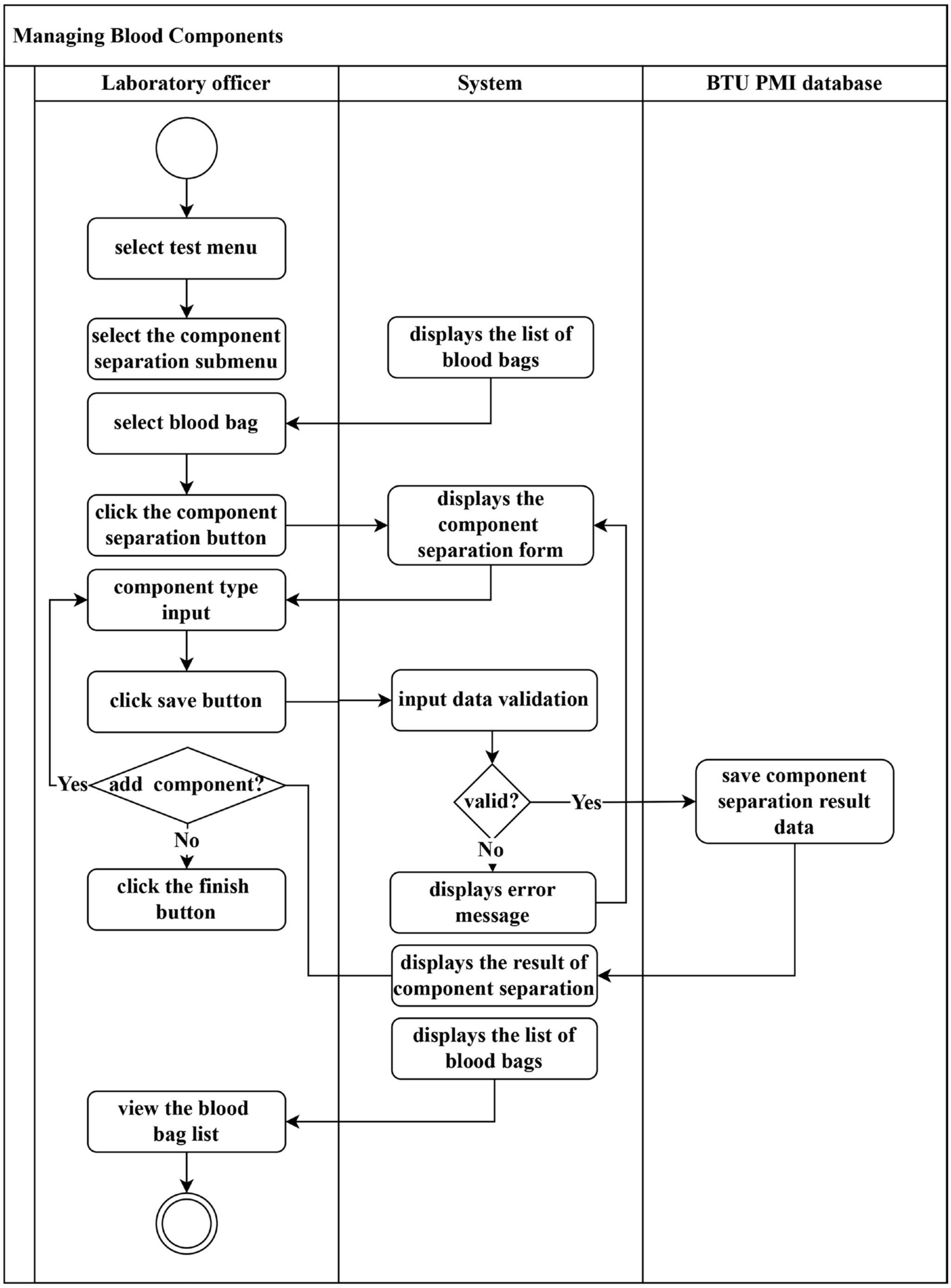

Fig. 4. Activity diagram managing the blood components system

Fig. 4 shows the procedure flow for laboratory personnel to enter blood component separation data into the system. The system will verify the entered blood component separation data. If the entered data is invalid, the system will display an error notification. After the entered data is validated, the system will save the blood component separation information in the Indonesian Red Cross Blood Transfusion Unit (BTU PMI) database.

4. 3. 3. Entity relationship diagram of a blood transfusion unit

The Entity Relationship Diagram (ERD) is one of the most important data modeling techniques in the database design process. ERDs are used to represent data in a conceptual form before being implemented into the actual database schema. By using an ERD, developers can illustrate the relationships between entities, the attributes possessed by each entity, and the types of relationships that occur between these entities [18].

The result of the entity relationship diagram (ERD) is a graphical representation of the relationships between entities designed for the blood transfusion unit database, from donor data to the screening process (Fig. 5).

By depicting the relationships between entities in the system, this diagram plays an important role in modeling the logical structure of the database.

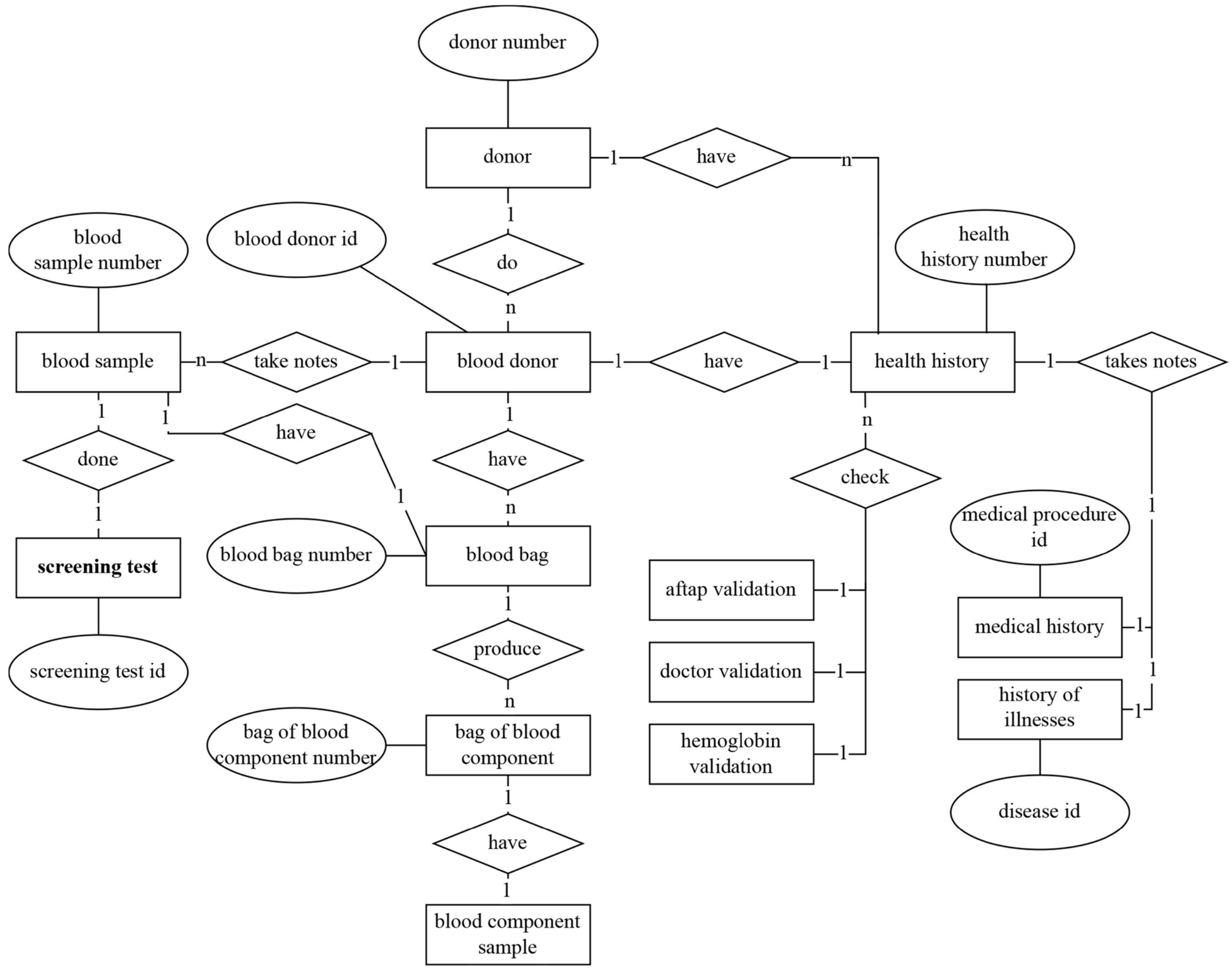

Fig. 5. Entity relationship diagram

4. 3. 4. Software architecture design for blood screening and blood bags

The results of this software architecture describe the login process up to the screening test in the Indonesian Red Cross blood transfusion unit, where the software architecture relies on various concepts that are in accordance with computer science including modeling, processes, human factors and technology (Fig. 6) [19, 20].

This architecture also serves as a basis for making decisions about system quality, performance, and security, user interface visualization, and coding methodology.

Fig. 6 shows the result of the blood and blood bag screening software design, there are 7 main processes in the system, namely login, donor management, health history management, HB validation management, doctor validation management, aftap validation management and screening test management.

4. 4. Implementation

After conducting literature studies, observations, and interviews with the head of the blood transfusion unit, the next step is to implement the system to be built. Based on data analysis, the author designs the application to be created [21].

Next, conducting a literature study, observation, and interviews with the staff of the BTU PMI. The system design begins with the development of the software architecture design (SAD), entity relationship diagram (ERD), relational tables, and unified modeling language (UML) design, which includes use case diagrams, class diagrams, sequence diagrams, and activity diagrams. The creation of the interface mockup uses Balsamiq software and a template from Bootstrap with the help of the NetBeans editor. Meanwhile, the program uses the PHP Laravel 5 Framework and the XAMPP package (PHP, MySQL, Apache Web Server). The program code is written using the NetBeans editor. The information system is implemented using the PHP Laravel framework version 5 and the XAMPP package (PHP, MySQL, Apache Web Server). To run the program, Mozilla Firefox and Google Chrome browsers are used.

This information system will process data on donors, medical history, HB validation, doctor validation, aftap validation, blood bags, blood samples, blood component bags, blood requests, patients, and screening tests. From the processed data, this study focuses on the management of blood bag screening tests and reports in the form of information on blood bags that have been screened.

The blood that has been screened and declared safe for transfusion can then be separated into blood components, namely whole blood (WB), packed red cells (PRC), leukocyte-depleted packed red cells (PRC-LD), thrombocyte concentrate (TC), fresh frozen plasma (FFP), cryoprecipitate AHF, liquid plasma, and buffy coat (BC).

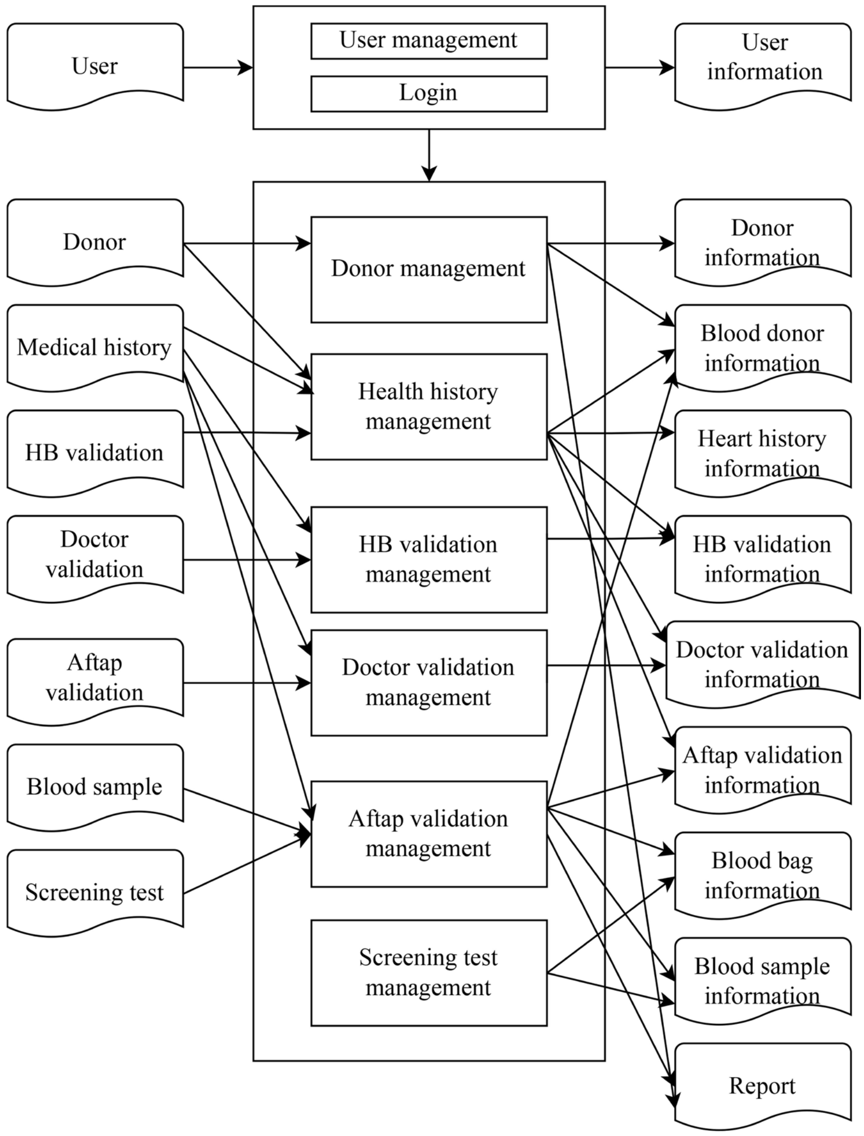

Fig. 6. Software architecture

4. 5. Testing and maintenance

After analysis, design and coding, testing is conducted, which is the most important step to ensure that the application functions according to the design [22].

The testing process is carried out using the black box testing method. In this method, the tester only pays attention to the input given to the system and the output produced. Input is data entered by the user, such as blood donor information in the context of a blood bag screening test management system. Using this input, the tester performs a series of tests to see if the output produced is in accordance with expectations. If the user enters valid blood donor data, the system will inform that the data is received and stored correctly. However, if the output does not meet expectations, this indicates a problem in the application's functionality that must be fixed.

At the maintenance stage, the last stage, the author handed it over to the blood transfusion unit officers who had been trained. Maintenance is carried out periodically to ensure that the application continues to run according to the flow created, and the data being run functions properly [23].

5. Results of the screening test study at the Indonesian Red Cross (PMI) blood transfusion unit

5. 1. Results of recording blood donation activities and donor data

Based on the needs analysis, the stages of the blood bag screening test protocol are as follows (Fig. 7):

– donor registration: blood bag management begins with recording donor data;

– medical history: recording donor data and history of illnesses suffered. If declared healthy, the donor is recorded in the database;

– hemoglobin validation: preliminary examination by hemoglobin officers, to record blood type, whether it is blood type A, B, AB or O, with positive rhesus factor and negative rhesus factor in red blood cells;

– doctor validation: an actor who checks donor data, checks donor health history data, checks HB, then validates the results of the examination;

– aftap validation: an actor who can see donor data, see health history data, see HB validation data, see doctor validation data, after all is complete and declared to meet the requirements, then aftap stores it in a database;

– screening test: aftap officers then take blood and record the donor's reaction on the form and donor card. Then record the blood bag data and blood samples. Aftap officers take blood and record the blood bag data and blood samples in the system. The blood bags are then screened by laboratory officers, and the test results are recorded in the system. Blood bags that are declared healthy will be separated from the components and laboratory officers record the results of the blood component separation in the system.

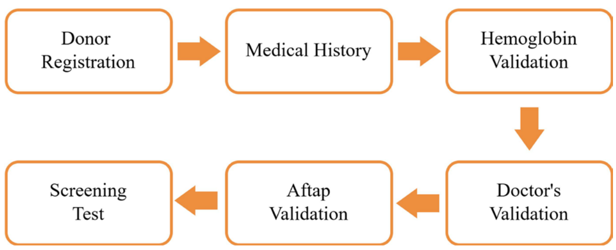

Fig. 7. Blood bag management flow

Table 1 blood_bag is used to manage donor blood bag data, including details such as collection, storage, and use. This Table 1 helps ensure traceability and compliance with safety and regulatory standards, which are crucial for patient safety and efficient inventory management.

Table 1

Blood bag

Field	Type
id_bag	varchar(15) NOT NULL
id_blood_donor	varchar(15) NOT NULL
status	enum('waiting', 'ok', 'done') NULL
created_by	int(15) NOT NULL
created_at	datetime NOT NULL
updated_by	int(15) NOT NULL
updated_at	datetime NULL

5. 2. Results of recording blood bag history activities

Table 2 presents Blood Component Bag in blood component management because it allows the storage of separation information and the status of each component in an organized manner.

By storing the history of separation, component type, and status, management can conduct analysis that helps improve the efficiency and quality of blood transfusion services.

Table 3 is used to store data generated from the separation of blood components. This table includes important information such as the type of component separated, the amount, and the associated medical conditions for the donor.

Table 4 is very important in the blood screening testing process, because it allows for the storage of organized and detailed information about each sample tested. By recording sample numbers, bag numbers, and screening result status, this table helps in decision-making related to blood transfusion and public health protection. The structured data in this table serves to support the improvement of service quality and monitoring of blood transfusion safety.

Table 2

Blood component bag

Field	Type
id_component_separation	varchar(20) NOT NULL
no_component_bag	varchar(15) NOT NULL
no_component_sample	varchar(15) NOT NULL
no_blood_bag	varchar(15) NOT NULL
no_blood_donor	varchar(15) NOT NULL
component_type	int(15) NOT NULL
separation_date	datetime NOT NULL
expiry_date	datetime NOT NULL
status	enum('INSTOCK',DELIVERED', 'PROCESS') NULL
created_by	int(15) NULLa
crteated_at	datetime NULL
updated_by	int(15) NULL
updated_at	datetime NULL

Table 3

Component separation

Field	Type
id_component_separation	varchar(20) NOT NULL
no_component_bag	varchar(15) NOT NULL
no_blood_bag	varchar(15) NOT NULL
component_type	int(15) NOT NULL
separation_date	datetime NOT NULL
expiry_date	datetime NOT NULL
created_by	int(15) NULL
created_at	datetime NULL
updated_by	int(15) NULL
updated_at	datetime NULL

Table 4

Blood sample

Field	Type
no_sample	varchar(15) NOT NULL
no_bag	varchar(15) NOT NULL
id_blood_donor	varchar(15) NOT NULL
screening_test	enum('WAITING', 'OK', 'NOTOK') NOT NULL
created_by	int(5) NOT NULL
created_at	datetime NOT NULL
updated_by	int(5) NULL
updated_at	datetime NULL

Table 5 is used to store data on laboratory screening test results performed on blood donor samples. The screening_test table is very important for tracking laboratory test results on blood donor samples, disease history and ensuring that any contaminants or health risks are identified before the blood is used in transfusion.

Table 5

Screening test

Field	Type
id_screening_test	varchar(20) NOT NULL
no_sample	varchar(15) NOT NULL
hepatitis_b	enum('Y', 'N') NULL
hepatitis_c	enum('Y', 'N') NULL
hiv	enum('Y', 'N') NULL
syphilis	enum('Y', 'N') NULL
blood_type	enum('A', 'B', 'AB', 'O') NULL
rhesus	enum('+', '-') NULL
status	enum('OK', 'NOTOK') NULL
component_separation	enum('WAITING', 'DONE',) NOT NULL
created_by	int(5) NULL
created_at	datetime NULL
updated_by	int(15) NULL
updated_at	datetime NULL

5. 3. Information on the availability of blood that has been screened

Fig. 8 shows the sample number, bag number, donor number, blood donor number, and action. This data is used to track blood donations and ensure proper handling of blood samples. Each of these identifiers is linked to a unique record in the system, helping to track blood donation history, monitor the status of each sample, and prevent errors during the blood distribution process.

Fig. 9 shows the sample number, bag number, donor number, blood donor number, hepatitis B, hepatitis C, syphilis, HIV/AIDS, blood type, status, and test date. This comprehensive data set ensures that every blood sample is thoroughly tested for critical pathogens, thus ensuring the safety of the recipient.

Fig. 10 presents the screening test page, a list of blood bags that will undergo screening tests. This page serves to ensure that all blood units are properly assessed for safety and compatibility before distribution. It is used to track the status of each test and systematically document the results, reducing the risk of errors in the screening process.

Fig. 11 is a form for adding blood sample screening test result data. This form allows users to enter test results systematically, ensuring that all required parameters are recorded accurately. It also facilitates data validation, helps streamline workflow and maintains the integrity of the screening process to improve decision-making.

Fig. 12 presents a list of screening test results for today's blood samples.

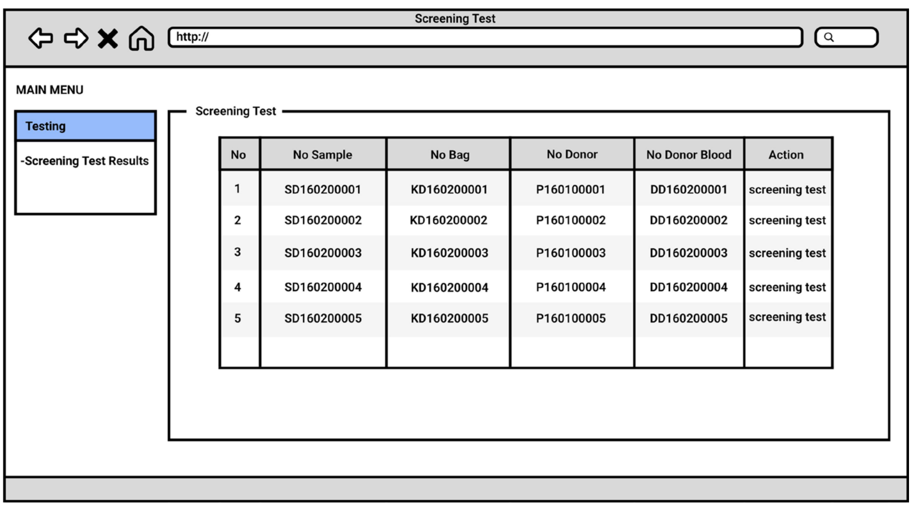

Fig. 8. Mock-up of screening test

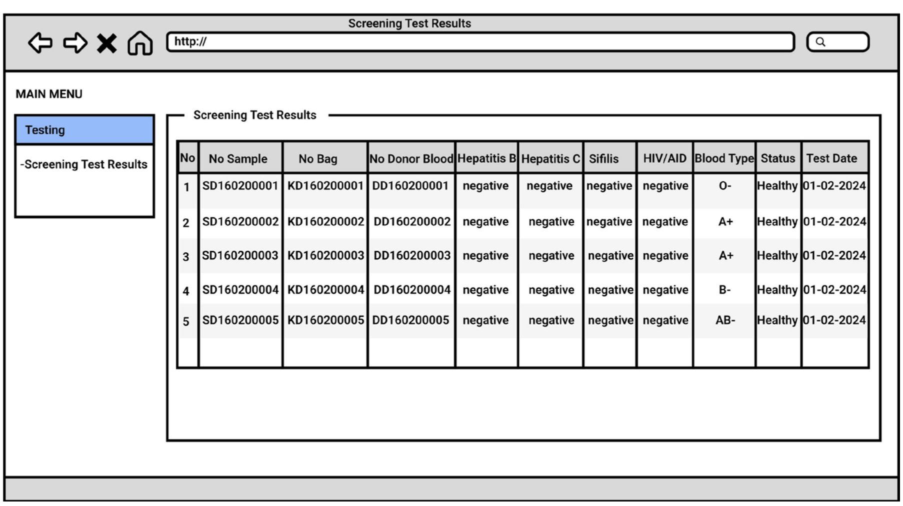

Fig. 9. Mock-up of screening test result menu

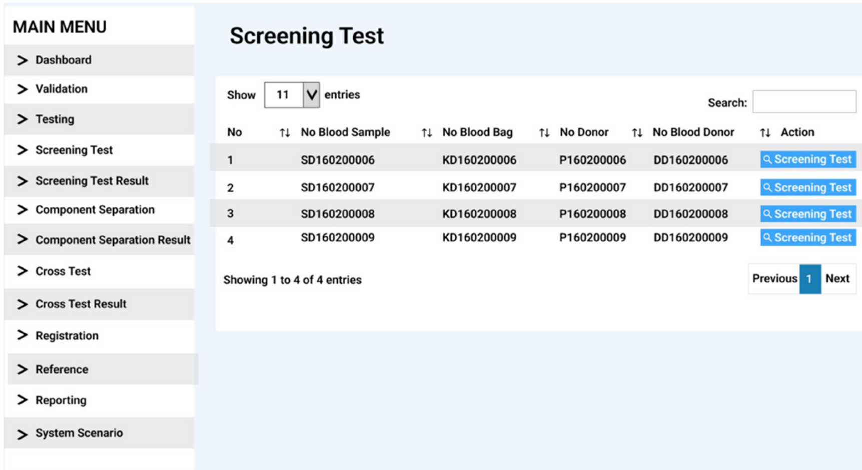

Fig. 11. Screening test result menu

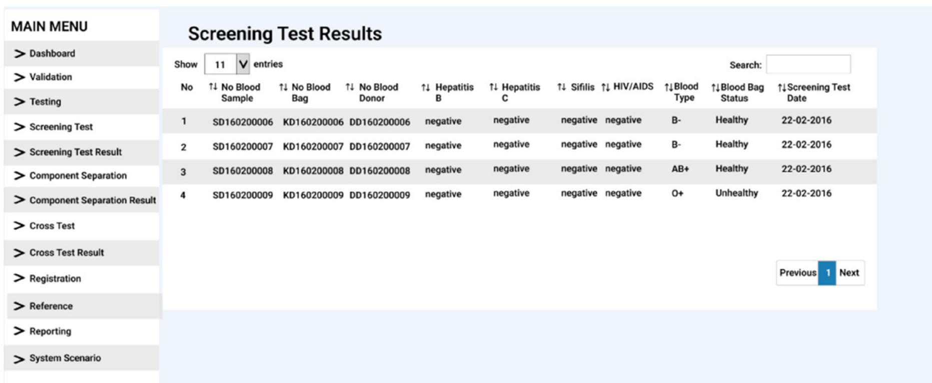

Fig. 12. Screening test results

This table helps ensure that all relevant data for each blood sample, including pathogen detection and compatibility details, are recorded systematically.

6. Discussion of results implementation of blood bag screening test in blood transfusion management in Indonesia

The importance of implementing blood bag screening tests in blood transfusion management in Indonesia is focused on efforts to improve transfusion safety through the implementation of systematic screening tests, considering the challenges faced in blood transfusion units, such as difficulties in recording donor data, blood bag data and delays in testing. In the background of the study, it was shown that a well-conducted screening test is able to detect potential risks of infection that can endanger blood recipients. Fig. 7 illustrates the flow of the screening protocol in the Indonesian Red Cross Blood Transfusion Unit (BTU PMI), which consists of 6 stages of manual recording to obtain screened blood bags. In this flow, each stage is managed by administrative officers and requires a lot of time. From the results of the preliminary study, the blood screening protocol revealed gaps in data management and testing efficiency. The manual process of the screening protocol often causes delays in testing and the risk of errors in testing blood bags. The proposed solution focuses on replacing manual methods with digital systems, which aim to reduce human error and improve the efficiency and quality of blood transfusion services. An example of this is data that is stored separately so that it is more organized (Table 2). Meanwhile, Fig. 8 shows how data is stored where each data is given a unique code number that appears automatically. The unique code is used to track and ensure proper handling of blood samples. In this case, each unique code is connected to the system to track the history of blood bags quickly. Fig. 9 shows how each unique code is connected to the history of hepatitis B, hepatitis C, syphilis, HIV/AIDS (positive code if detected and negative code if not detected), blood type (O, A, B, AB, which is marked with rhesus positive and rhesus negative), blood sample status (healthy or not) and the date of testing. These data are recorded to ensure that each blood sample is tested thoroughly. Table 5 is used to store data on laboratory screening test results performed on blood donor samples. This table helps to track laboratory test results on blood donor samples, ensuring that any contaminants or health risks are identified before the blood is used in transfusion. After that, the laboratory officer will display a list of blood bags that are ready to undergo screening tests. Fig. 10 shows a list of blood bags that will undergo screening tests. This page can display a list of blood samples that the officer wants. This is very helpful for laboratory officers, because it provides an efficient workflow and documents test results systematically. While in Fig. 11 is a page to display additional data on blood sample screening test results. This page helps officers to enter screening test results systematically and accurately.

From the explanation above, it is clear that the new method can speed up the process of managing blood bag screening tests because the old method still uses a manual method. The results can be seen in Fig. 12, which shows a table of screening test results for blood samples, recording all relevant data, including pathogen detection. This can quickly help blood transfusion unit officers to check and trace blood safety quickly. This is important if there is a sudden request for blood. This is because donor data and blood samples are still recorded using Microsoft Excel. Meanwhile, making reports takes a long time if the data managed is large and not easily accessible. Many traditional blood banks still rely on paper-based (manual) systems, so they fail to meet emergency blood requests like that [24]. This is the system currently used in the Indonesian Red Cross blood transfusion unit.

Integration between legacy system management methods and new systems is essential to ensure operational efficiency. Designing software from blood samples to screening tests is the author's proposed solution to address the above issues (Fig. 7). This new method allows for a smoother and more responsive workflow, taking into account the need for better integration.

The effectiveness of the new system was assessed through a series of evaluations focused on its impact on blood safety and operational efficiency. The results showed a significant reduction in the time required for testing and a marked improvement in the accuracy of screening results. Feedback from healthcare professionals indicated a higher level of confidence in the safety of donated blood, leading to increased public trust in blood transfusion services.

High infection rates in blood transfusions are a serious problem identified, especially related to the implementation of blood bag screening systems. The implementation of automated screening methods has shown a significant reduction in infection rates, as evidenced by the data collected after implementation. As explained in Section 5. 3, the automated screening process facilitates contamination detection, making it more efficient. This efficiency is reflected in Fig. 12, which illustrates the improvement in detection capabilities, indicating a decrease in infection rates thanks to the implementation of this solution.

The last problem is the real-time reporting that takes a long time, which can result in a slow response to contamination issues in blood transfusion. The proposed solution is to perform real-time data analysis, which allows for immediate response when blood contamination is detected. As explained in Fig. 7, the delay in reporting can worsen this problem. Meanwhile, Fig. 7 shows that the response time using this new system can be directed more efficiently.

The blood bag management information system includes several features and protections that go beyond just registering for blood tests. Here is an explanation:

a) other features besides registration for tests:

1) donor and blood bag data tracking: this system not only records donor registration, but also manages donor health history, blood availability information, and screening test results in real-time. This helps in ensuring that the data used is up-to-date and accurate;

2) reporting and monitoring: the system provides easily accessible reports to monitor blood donor operations, enabling better decision-making in transfusion management;

3) data integration: the system integrates data from multiple sources, including test results and donor information, making it easier for healthcare workers to conduct analysis and decision-making;

b) system protection:

1) data security: the system must adhere to strict data security and privacy standards, including the use of encryption technology to protect sensitive donor and patient information;

2) access control: only authenticated AFTAP personnel can access certain information, ensuring that data is only accessible to authorized parties;

3) audit trail: the system implementation may include an audit trail feature to track all activity within the system, so that any changes to data can be monitored and traced back;

c) authentication services.

While authentication services are an important part of system protection, the system also includes various other layers of security. These include:

– role-based authorization: each actor in the system (such as administrators, doctors, and laboratory personnel) has limited access based on their roles, thereby reducing the risk of data misuse;

– security monitoring: the system can be equipped with security monitoring to detect suspicious activity or security breaches in real-time.

Thus, the blood bag management information system not only focuses on test registration but also includes various advanced features to improve efficiency and security in blood transfusion management.

Choosing the Waterfall method to complete software development. The Waterfall and Agile methods are two commonly used approaches in software development. The choice of the Waterfall method is because this method is more structured and linear, while Agile is a more flexible and responsive approach [25]. In the context of implementing blood screening tests as part of transfusion management, the Waterfall method is more suitable than Agile, for the following reasons:

a) clear structure of steps in each phase;

b) complete documentation, which is essential in the implementation of thorough screening tests for compliance with strict health standards;

c) minimal changes during the process, ensuring stability after the design phase is completed;

d) time and budget management, with a clear design this method can help manage the time and budget of BTU PMI.

The creation of a blood screening test management system has predetermined requirements. Waterfall is more suitable for environments that require certainty and not much adjustment during the process. Although the Agile method offers flexibility and adaptation, this approach can create uncertainty in the management of blood bags that require high certainty and accuracy.

The limitation of this study is that this system can only be used internally at BTU PMI. This is because the system was created by adjusting the provisions applicable at BTU PMI. In addition, the system also has limitations related to the application of the screening system in various locations or different contexts, so the results may not be widely adapted.

The proposed automated screening system is highly dependent on technology, which is susceptible to technical failures, maintenance issues, or software bugs. In practice, blood transfusion units must ensure that they have the support and infrastructure to continuously maintain and troubleshoot the system.

Successful implementation depends on staff competence in operating the new system. Resistance to change or lack of training can hinder its effectiveness. An adequate training program is essential to facilitate a smooth transition to the new system. Limitations in training resources can impact user engagement and system effectiveness. Future studies may investigate best practices for user training and support.

The solution must comply with local regulations and standards regarding blood screening and transfusion safety, which can vary by region. When implementing the solution, it is essential to ensure compliance to avoid legal issues and ensure patient safety. The initial investment to implement the proposed solution may be substantial, potentially limiting its application in resource-constrained settings. A cost-effectiveness analysis should be conducted to demonstrate the long-term savings resulting from improved screening capabilities. The long-term effectiveness of the screening solution in maintaining low infection rates over time is uncertain. Ongoing monitoring and evaluation will be required to assess the ongoing performance of the system.

A limitation of this study is that much of the data was missing from the legacy system or untraceable, which had to be discarded. Without historical data, it is difficult to determine whether early positive results, such as reduced infection rates, were sustained over time. This can lead to unrealistic expectations about the effectiveness of the intervention. Another limitation is that the study did not adequately address the qualitative aspects of user experience and satisfaction with the new system. The study focused heavily on technical metrics, such as infection rates, while ignoring other important factors, such as cost-effectiveness and logistical challenges.

This research development opportunity covers several important aspects that can improve the effectiveness of the proposed blood bag screening solution:

1. Long-term research could provide insight into the sustainability of the benefits of the solution, helping to understand how the system functions over time and whether initial successes can be maintained.

2. Expanding the trial to a range of blood transfusion units in Indonesia, including those in rural or resource-limited areas, will assess its adaptability and effectiveness across environments, thereby increasing the generalizability of the results. User experience research is also important to gather feedback and satisfaction, which can improve the usability and design of the system according to the needs of healthcare professionals.

3. A thorough cost-benefit analysis would help justify the investment to stakeholders by ensuring financial considerations are well addressed.

4. Integration of advanced technologies such as artificial intelligence (AI) or machine learning algorithms can improve the efficiency and accuracy of the screening process, while regulatory framework adjustments through collaboration with regulatory bodies will legitimize this new method.

5. Comprehensive training programs for healthcare professionals are also critical to successful implementation, ensuring staff are able to use the system effectively.

6. Collaborative research with other research institutions and universities could enrich the exchange of knowledge and explore additional relevant variables and technologies in blood screening.

From the description above, it can be highlighted that the implementation of blood bag screening tests is very important in blood transfusion management in Indonesia.

1. Detection of infectious diseases: the author emphasizes that screening testing is a crucial step to detect infectious diseases that can be transmitted through blood transfusion, such as hepatitis B, hepatitis C, HIV, and syphilis. By conducting this test, the risk of spreading infection to blood recipients can be minimized.

2. Patient safety: screening testing contributes to patient safety by ensuring that only blood that has been tested and found safe is used for transfusion. This is critical in maintaining the integrity of the healthcare system and public confidence in blood transfusion services.

3. Quality standards: the authors state that well-conducted screening tests are part of the quality standards that blood transfusion units must adhere to. This process not only protects patients but also enhances the overall reputation of the health service.

4. Adaptation to new threats: the authors note that despite the advancement of testing technologies, new disease threats continue to emerge. Therefore, monitoring blood quality and implementing rigorous screening procedures are becoming increasingly important to address dynamic health challenges [26].

5. Need for an effective information system: in this context, the authors also point out that the proposed information system can improve the effectiveness of screening tests by providing tools to efficiently record and manage data, enable real-time tracking of test results and facilitate better decision-making.

Thus, the importance of screening testing in this paper is emphasized as a fundamental element in safe and quality blood transfusion management in Indonesia, as well as part of efforts to protect public health as a whole.

7. Conclusions

1. The system that was built successfully recorded blood donor activities and donor data efficiently, increased the accuracy and accessibility of information, and supported better data management in blood transfusion units in Indonesia. This result is an original finding because the system was designed to address the problems of inaccuracy and lack of access to information in the previous manual system. This success is demonstrated by the increase in accuracy and speed in data recording, as well as the ease of access to information for health workers.

2. The developed system successfully records blood bag history effectively and in an organized manner. The system stores important information such as processing data, blood component type, separation date, and expiry date. This enables data analysis that can improve the efficiency and quality of blood transfusion services. This finding is also an original result because the system addresses the issues of inaccuracy and unavailability of data in the previously existing manual system. Its success is evidenced by the increase in data accuracy and completeness, as well as the reduction in the risk of errors in blood bag management.

3. The system provides real-time information on blood availability, enabling rapid response to transfusion needs, and improving operational efficiency in blood transfusion units in Indonesia. The system successfully provides intuitive and easily accessible reports, providing a solid basis for monitoring blood donor operational activities and supporting better decision-making. This finding is an original result

because the system was designed to address the problems of delays and inappropriate decision-making in the previous manual system, as evidenced by the ease of accessing real-time information and reducing response time to transfusion requests.

Conflict of interest

The author has no conflict of interest related to the current research, whether financial, personal, authorshipp or otherwise, that could affect the research, as well as the results reported in this paper.

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Data availability

Data cannot be made available since it is confidential.

Use of artificial intelligence

The author confirms that he did not use artificial intelligence technology when creating this work.

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