



ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF INFORMATION SCIENCE

**DESIGNING A KNOWLEDGE BASED SYSTEM FOR BLOOD
TRANSFUSION:**

GUESH DAGNEW

JUNE, 2012

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF INFORMATION SCIENCE

DESIGNING A KNOWLEDGE BASED SYSTEM FOR BLOOD TRANSFUSION

**A Thesis Submitted to the School of Graduate Studies of Addis Ababa University
in Partial Fulfillment of the Requirements for the Degree of Master of Science in
Information Science**

BY
GUESH DAGNEW
JUNE, 2012

ACKNOWLEDGEMENT

First of all, I would like to thank the Almighty God, for helping me to reach this level. Next, I would like to express my heart-full gratitude and thanks to my advisor Ato. Getachew Jemaneh, for his invaluable support, and kind approach which I found very important for the accomplishment of this work.

My gratitude thanks is extended to Dr. Million Meshesha for helping me to have the determination in doing this study during my proposal selection and his invaluable comments at the end, to be honest, directly or indirectly without his support; this work could not be realized. Beyond that I appreciate and thanks for the dedication he has in teaching profession for his support during my stay in the School of Information Science.

I thank the community of school of information science for all the supports, moral and encouragements. Special thank goes to all my classmates for being with me when help is needed, and for all the share of their practices which I use as an input to accomplish my thesis.

Particular mention goes to my friend, Solomon G/Mariam, for his positive comments, ideas, advice and contributions during this study time.

I would like to express my thanks to Ato Dersisa Fufa, head of the Blood Bank in Black Lion hospital for his continuous follow-up throughout the study period. I thanks to all the staff of the Blood Bank section of Black Lion Hospital for their cooperation throughout the study period.

I have to thank my family for all the invaluable supports, moral and encouragement and Dire Dawa University for the financial support.

ACRONYMS

1. A-	Negative Blood Type A
2. A+	Positive Blood Type A
3. AB-	Negative Blood Type AB
4. AB+	Positive Blood Type AB
5. ABO	Blood types A, B, AB & O
6. AI	Artificial Intelligence
7. ANN	Artificial Neural Networks
8. B-	Negative Blood Type B
9. B+	Positive Blood Type B
10. CRC	Concentrated Red Cells
11. FOL	First Order Logic
12. KA	Knowledge Acquisition
13. LISP	List Programming
14. O-	Negative Blood Type O
15. O+	Positive Blood Type O
16. RBC	Red Blood Cell
17. RH Factor	Rhesus factor

TABLE OF CONTENTS

ACKNOWLEDGEMENT	I
ACRONYMS	II
TABLE OF CONTENTS.....	III
LIST OF FIGURES	VII
LIST OF TABLES	IX
ABSTRACT	X
CHAPTER ONE	1
INTRODUCTION.....	1
1.1. Background of the Study	1
1.2. Statement of the Problem	3
1.3. Objective of the Study.....	5
1.3.1. General Objective	5
1.3.2. Specific Objectives	5
1.4. Methodology of the Study	6
1.4.1. Literature Review.....	6
1.4.2. Knowledge Acquisition and Knowledge Representation	6
1.4.3. Knowledge Base System Design	6
1.4.4. Testing Procedures	7
1.5. Scope and Limitation of the Study.....	7
1.6. Significance of the Study	8
1.7. Organization of the Thesis	8
CHAPTER TWO	10
LITERATURE REVIEW	10
2.1. Introduction to Blood Transfusion	10

2.2.	History of Blood Transfusion	12
2.3.	Blood Types.....	13
2.4.	Blood Transfusion Procedures and Life Cycle	15
2.5.	Knowledge Based Systems.....	17
2.6.	Structure of Knowledge Base Systems.....	20
2.6.1.	Knowledge Base.....	21
2.6.2.	Inference Engine	25
2.6.3.	Knowledge Acquisition	27
2.6.4.	Explanation Subsystem.....	28
2.6.5.	The Human Element of knowledge Based Systems	29
2.6.6.	User Interface.....	30
2.7.	Inference with Uncertainty	31
2.8.	Knowledge Based Systems and Conventional Programs	31
2.9.	Application of Knowledge Based Systems.....	32
2.9.1.	Related Research Works to Blood Transfusion	32
2.10.	Representing Knowledge.....	34
2.10.1.	Knowledge Representation in Frame-Based Systems	35
2.10.2.	Knowledge Representation in Production Rules	35
2.11.	Testing and Evaluation of the KBS.....	36
CHAPTER THREE.....		37
3.1.	KNOWLEDGE ACQUISITION	37
3.2.	Knowledge Elicitation Methods.....	38
3.2.1.	Tacit Knowledge Elicitation.....	39
3.2.2.	Explicit Knowledge Elicitation	41
3.3.	Knowledge Structuring.....	47

3.4.	Knowledge Base Models	47
3.4.	Knowledge Modeling for Blood Transfusion	48
3.4.1.	Blood group Donor (O Negative).....	49
3.4.2.	Blood Group Donor (O Positive)	49
3.4.3.	Blood Group Donor (A negative).....	50
3.4.4.	Blood group Donor (A Positive)	50
3.4.5.	Blood group Donor (B Negative)	50
3.4.6.	Blood Group Donor (B Positive).....	51
3.4.7.	Blood group Donor (AB Negative)	51
3.4.8.	Blood Group Donor (AB Positive).....	52
3.4.9.	Plasma Compatibility Structuring	52
3.4.10.	Platelet Compatibility Structuring.....	53
3.4.11.	Donor and Recipient Blood Compatibility Model for Whole Blood Transfusion	55
CHAPTER FOUR		57
4.1.	Knowledge Representation and Prototype Development	57
4.2.	Knowledge Representation for Blood Transfusion.....	57
4.3.	Knowledge Base for Blood Transfusion	67
4.4.	Inference Engine	68
4.5.	Explanation Facilities.....	69
CHAPTER FIVE		74
5.1.	System Testing and Evaluation	74
5.1.1.	Discussion on How the System Works.....	75
5.2.	Testing and Evaluation.....	80
CHAPTER SIX		85
6.	CONCLUSION AND RECOMMENDATION	85

6.1. Conclusion.....	85
6.2. Recommendations	86
REFERENCES.....	87
APPENDICES	95
Appendix II: The Knowledge Based System Code for Blood Transfusion	96
Appendix III: Sample Knowledge Base Derived from the Rules	121
Appendix IV: Interview Questions for Elicitation of Knowledge from Experts on Blood Transfusion...	125
Appendix V: Questionnaire for Testing and Evaluation of KBS with Domain Experts.....	126
Appendix VI: Test Design to be performed by one domain expert.....	127

LIST OF FIGURES

Figure 2.1: Blood transfusion procedures	17
Figure 2.2: Structure of Knowledge Based System.....	20
Figure 2.3: Semantic Net Examples	24
Figure 3.1: Concept Hierarchy Ladder for Blood Transfusion Categories	48
Figure 3.2 : Model For RBC Group O Negative Donates To the Leafed Blood Groups (Recipients ABO)	49
Figure 3.3: Model for RBC Blood Group O Positive Donation to the Leafed Blood Groups (Recipients ABO)	49
Figure 3.4: RBC Blood Group A Negative Donates to the Leafed Blood Groups (Recipients ABO)	50
Figure 3.5: Model for RBC Blood group A positive donation to the leafed blood groups (Recipients ABO)	50
Figure 3.6: Model for RBC Blood Group B- Donation to the Leafed Blood Groups (Recipients ABO)...	51
Figure 3.7: RBC Blood Group B+ Donation to the Leafed Blood Groups (Recipients ABO)	51
Figure 3.8: Model for RBC Blood Group AB- Donation to the Leafed Blood Groups (Recipients ABO)	52
Figure 3.9: Model for RBC Blood Group AB+ Donation to Recipients Blood Groups (AB+).....	52
Figure 3.10: Model for Plasma Blood Group O Donation to Recipients' Blood Groups (O).....	52
Figure 3.11: Model for Plasma Blood Group A Donation To the Leafed Recipients Blood Groups (O & A).....	52
Figure 3.12: Plasma Blood Group A Donation to the Leafed Recipients Blood Groups (B & O).....	53
Figure 3.13: Model for Plasma Blood Group A Donation to the Leafed Recipients Blood Groups (O, A, B, AB).....	53
Figure 3.14: Model for Platelet Blood Group O Donation to the Leafed Recipients Blood Groups (O, A, B, and AB)	54
Figure 3.15: Model for Platelet Blood Group A Donation to the leafed Recipients Blood Groups (A, AB, A and O)	54

Figure 3.16: Model for Platelet Group B Donation to the leafed Recipients Blood Group (B, AB, A and O).....	54
Figure 3.17: Model for Platelet Group AB Donation to the leafed Recipients Blood Group (AB, A, B and O).....	54
Figure 3.18: Model for Whole Blood Transfusion	55
Figure 4.1: Architecture of the System.....	57
Figure 4.2: Example of Inference (Forward Inferencing).....	71
Figure 4.3: Sample Inferencing Dialog Between the system and the User	72
Figure 4.4: Sample Dialog of “WHY-NOT” Explanation Facilities	73
Figure 5.1: A Snapshot to the Welcome window of the Blood transfusion Knowledge Based System.....	74
Figure 5.2: Sample snapshot for Red Blood Cell Transfusion Decision	76
Figure 5.3: Sample snapshot for Plasma Cell Transfusion Decision.....	77
Figure 5.4: Sample snapshot for Platelet Blood Cell Transfusion Decision.....	78
Figure 5.5: Sample Snapshot for Whole Blood Transfusion (Non-compatible ABO Group)	78
Figure 5.6: Sample Snapshot for Whole Blood Transfusion (Non-compatible Room Temperature)	79
Figure 5.7: Sample Snapshot for Whole Blood Transfusion (Non-urgent Whole Blood Transfusion).....	80

LIST OF TABLES

Table 3.1: RBC Blood Cell Compatibility (Considering RH factor)	42
Table 3.2: Plasma CompatibilityNegative	44
Table 3.3: Selection of ABO Compatible for packed CRC	45
Table 3.4: Selection of ABO Compatible Blood for Plasma	46
Table 3.5: Selection of ABO Compatible Blood for Platelet	46
Table 5.1: Summary of Test results by Specialist (Domain Expert)	82
Table 5.2: Summary of Test Results by Nurses (Domain Experts).....	82
Table 5.3: Summary of Average Test Results by Nurses and Specialist	82
Table 5.4: Summary of Users Evaluation for the System by One Domain expert Specialist	83
Table 5.5: Users Evaluation of the system by Five Domain experts (Nurses).....	83

ABSTRACT

Transfusing the right blood to the right patient is the intention of blood transfusion in many health care organizations. Blood transfusion in Ethiopia takes place in hospitals, but collecting blood from donors takes place in the National Blood Bank, which is under the Ethiopia Red Cross Society. However, still hospitals can collect and transfuse for urgent and regional cases. Currently, there is a gap of expertise among health professionals involve in blood transfusion, such as shortage of knowledge, which blood type for whom. Developing knowledge-based system to support professionals involve in blood transfusion helps to solve the problem, and is found to be feasible to develop a knowledge-based system within the area of blood transfusion. In this study, a knowledge-based system prototype is developed for blood transfusion. This system will minimize the errors committed such as, which blood type should be transfused for patients in need of urgent or non-urgent transfusion requirements. The system registers a promising and encouraging performance result which is highly applicable. Target users are keen that the system is a clinching effort hence, valuable support in blood transfusion is expected of the system. Users need to provide patients profile such as name, gender and age-group before proceeding to the next blood product options. For whole blood transfusion, users need to test blood type compatibility, room temperature test and decision of urgent and non-urgent issues. For the other blood products, red blood cell, Platelet and plasma, selecting the blood type of a patient is done, and then the system will generate the appropriate blood type sequentially. The output of this study is applicable to training of newly employed health professionals in blood transfusion and for teaching aid in hematology courses within the field of medicine. This study is done first by problem identification followed by tacit knowledge extraction by using interview and observation. For explicit knowledge elicitation, document analysis such as manuals and books is done. The acquired knowledge from domain experts and document analysis is modeled using hierarchal knowledge representation. Then the knowledge is represented in production rule (If-Then-Action) and the prototype is developed using SWI-prolog editor environment. The system works using the forward inference mechanism. The system is tested and evaluated by users, and promising result was registered. The system can be applicable to blood transfusion, since it registers 82.5% complete knowledge for the task.

Key Words: *Blood Transfusion, Whole Blood, RBC, platelet, plasma, KBS, Prolog, knowledge acquisition, knowledge representation*

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Blood transfusion is an issue of life-saving intervention, which has a fundamental role in patient treatment and management in many health care organizations. It is an essential and indispensable part of patient care and health care delivery, which saves lives. Blood transfusion is a common procedure in which a donor's blood is infused into the patient's blood to replace missing blood due to illness and emergency cases. That is why; many health care organizations attempt to establish well organized blood transfusion services, which can provide sufficient and timely supply of safe blood to meet the transfusion needs of the patient population (Neelam, 2010).

Well organized blood transfusion service with quality systems is required for safety and effective use of blood and blood products. Blood transfusion is a key component of health care delivery systems. This is required for protection of transfusion transmitted infections and provision of safe and adequate blood supply to blood recipients. There are three main phases in blood transfusion as systems which are; collection of blood from the donors, screening of the blood by experts using laboratory practices and distribution or transfusion of blood to recipients (Sujatha, 2007).

The distribution or transfusion of blood to recipients has been identified as a task whereby knowledge-based systems can make a positive impact upon patient care with the help of technology. There is a concern about blood transfusion transmitted issues with respect to the goal of standardizing transfusion practices (Thomas, Osuntogun, Pitman, Mulenga, and Vempala, 2009).

Blood transfusion is a safe process that saves lives and improves the quality of life in a large range of clinical conditions. Blood transfusion service is the way of undertaking blood donation with the help of supervision of trained personnel for all who need it in a safely manner irrespective of their economic or social status through comprehensive, efficient and a total

quality management approach. A deficiency in the quality of blood will impair the quality of life and even compromise life itself (Sujatha, 2007).

Establishment of knowledge-based systems (KBS) to ensure that donated blood is screened for transfusion transmissible infections is a core component of most national blood programs. Most blood banks are not equipped with licensed physicians qualified by training and experience as transfusion medical, technical and administrative servants (Neelam, 2010).

The goal of a knowledge base system is to understand and develop computational models of human intelligence. Knowledge based systems are part of artificial intelligence, which is originally designed to solve problems by applying knowledge of domain experts (Thomas, et al., 2009). One of the earliest applications of expert systems in a biological discipline was in the medical area (Mohamed and Julie, 2009).

As they are very rich in domain knowledge, knowledge-based systems (KBS) quickly became an essential tool for diagnostics and treatments in the medical area. Knowledge base systems are widely used in domains where knowledge is more common than data and that require heuristics and reasoning logic to derive new knowledge. The knowledge in knowledge base systems is stored in a knowledge base that is separate from the control and inference programs and can be represented by various formalisms, such as decision tree, Bayesian networks, production rules and neural networks (Mohamed and Julie, 2009).

In the field of blood transfusion, the evolution of medical knowledge and governmental regulation impose a continuous adaptation of decision support systems. First generation knowledge base systems use a single representational technique such as production rules, which are applicable by representing all the knowledge extracted from experts to make the knowledge-based systems more complete (Reid, 1985).

To overcome the limitations of the first generation of medical knowledge-based systems (KBS), other methods such as ontology based knowledge acquisition and knowledge representation techniques are evolving nowadays (Spackman and Connelly, 1987).

1.2. Statement of the Problem

Blood transfusion is a task performed in many health organizations to save patients' life. There is a great variation in how the task of blood transfusion carries out from one to other health organizations. This is due to lack of common standard and scarcity of professionals.

There is a gap in the degree of knowledge of the experts who are responsible for blood transfusion due to experience and educational exposure. As a result of this, problems such as miscommunication among physicians who order blood transfusion and medical laboratory technicians and nurses who perform the actual work happen. What type of blood for which patient, is a critical issue and mostly create a gap among physicians and technicians.

This is because, patients in need of blood may not get the right blood that matches their requirement, and they can be infected due to lack of screened blood. Hence, they can face poor quality of life due to the infected blood received.

The problem becomes worst and critical in developing countries than in developed countries due to several factors, such as scarcity of experts, lack of awareness of society on how blood transfusion is carried out and less use of the output of technologies in the area (Thomas et al., 2009).

According to World Health Organization report (2008), blood transfusion is an essential component of health care, which saves millions of lives each year. Every second, someone in the world is in need of blood for surgery, trauma, severe anemia or complications of pregnancy. The world health organization in 2008 estimated that although 80% of the world's population lives in developing countries, these countries only collect 45% of the global blood supply.

Related research works on design and implementation of a web-based tool to monitor the collection, screening and distribution of blood in developing countries have been done. This research work was conducted under the sponsorship of the US President's Emergency Plan for AIDS Relief (PEPFAR), which funds blood safety projects in 14 African countries, including Ethiopia, and the Caribbean (Thomas et al., 2009)

There is no research done in the area of blood transfusion in Ethiopia, except governmental policies and strategies regarding health issues. The initiation for this study is to launch the research by building a knowledge base for blood transfusion in the medical area.

In developing countries, there is no centralized information and knowledge management in most health service organizations. Experts can violate the procedures of blood transfusion processes that recipients can get reactive blood, which passes through low quality treatments and leads them to higher risk of life. On the other hand, non-reactive blood can be discarded as reactive hence creates wastage of blood resources. This is due to lack of enough expertise and lack of concentration, which knowledge base system developed within the area can be an appropriate solution (Sujatha, 2007).

In developed countries, the risk of transmission of known viral diseases with blood transfusion is currently rare. On the other hand, blood transfusion in developing countries is full of risk of viral transmission due to reasons such as administering of miss-matched blood type and unscreened blood transfusion (Ferraris, Ferraris, Saha, Eugene, Haan, David, 2007).

The aim of this study is to acquire knowledge necessary in blood transfusion and designing a knowledge base system that can provide advice to experts involved in blood transfusion.

Hence in this study, an attempt is made to address the following research questions.

- What type of knowledge is required to design a knowledge base system which can assist experts in blood transfusion?
- How the qualities of blood transfusion processes be improved using knowledge based system so as blood transfusion has no adverse reactions or infections, which benefit the patient.
- How to avoid incompatible blood transfusion using knowledge-based system and administer the transfusion only when it is necessary.

1.3. Objective of the Study

1.3.1. General Objective

This research attempts to design a knowledge base system that can provide a significant help for domain experts involve in the area of blood transfusion such that patients in need of blood transfusion can get the right blood timely. To promote improvements to the quality of blood transfusion processes such as safe blood transfusion in a way, no adverse reactions or infections occurred, clinically effective, which benefits the patient and efficient in a manner, no unnecessary transfusions take place, and transfusion should administer at the time when the patient needs it. The gaps created among domain experts on the area of blood transfusion will be minimized due to the common understanding obtained from the system.

1.3.2. Specific Objectives

- To review documents related to blood transfusion to have conceptual understanding about the rules and procedures.
- To understand concepts that can be helpful in designing knowledge base systems for blood transfusion.
- To extract knowledge from domain experts and manuals in the area of blood transfusion
- To model and represent the acquired knowledge using appropriate knowledge representation technique.
- To develop a prototype knowledge base system that can assist experts during blood transfusion.
- To test the performance of the prototype and evaluate its reliability and performance with respect to the view of experts in the field of blood transfusion
- To give recommendations based on the findings and to pave the way for further research works in the area.

1.4. Methodology of the Study

1.4.1. Literature Review

In this study; materials such as journals, related works and manuals, which are helpful for the enhancement of the research were reviewed. Documents related to blood transfusion were reviewed and the necessary documents and tools for the development of the prototype were also reviewed.

1.4.2. Knowledge Acquisition and Knowledge Representation

The necessary knowledge in this study was acquired and elicited using a directive interviews to the medical experts, specifically the specialist (general practitioner) in the area of blood transfusion and laboratory technicians. A secondary data from documents such as manuals was also assessed. Furthermore, in this study demonstration and direct observation were considered to acquire the necessary knowledge for designing knowledge base system for blood transfusion.

1.4.3. Knowledge Base System Design

In this study, the elicited knowledge from domain experts was constructed and modeled in a hierarchical tree and decision tree, which were found to be suitable for developing prototype knowledge base system for blood transfusion.

The researcher selected a rule based knowledge representation method to represent the relationship between facts and rules in the form of IF-THEN, which shows condition-action relationships.

In rule based knowledge representation, the knowledge is represented by symbolic rules and inference in the system is performed by a process of chaining through rules recursively, either by reverse or forward reasoning (Mohamed and Julie, 2009).

There are many programming languages and tools used to develop knowledge-based systems, some of which are Lisp, prolog and Clips (Aronson and Turban, 2007). Programming languages Prolog and Lisp environment rank high in the field of artificial intelligence (AI) research. LISP is an older general-purpose language used to build a program, which imitates human behavior while Prolog came later and focuses on knowledge bases and expert systems.

Lisp is one of the oldest high-level computer programming languages, and is a general purpose language which has a rich set of data types as well as built-in data structures like lists, trees and maps. On the other hand, Prolog is a declarative programming language that specializes in inference-based reasoning. It uses specialized logic to derive new knowledge from a list of rules known as a knowledge base. The language works well for tasks like proving mathematical theorems and building knowledge and expert systems.

In this study, SWI-prolog programming language is used to build the knowledge base of the system.

1.4.4. Testing Procedures

According to Hope and Meseguer (1993), testing is the process of determination of the correctness of a program with respect to the user needs and requirements. Verification deals with ensuring that a system correctly implements specific functions, which satisfies its specification whereas validation is all about determining whether the system satisfies expected goals.

In this study, the system is tested and evaluated for its performance by the domain experts in the area of blood transfusion. The reasoning of the knowledge base system was compared with experts reasoning; with respect to whole blood, plasma, platelets and red blood cell (RBC) transfusion. The difference of the knowledge base system and experts reasoning was measured using the summary of the output of the evaluation. Finally the recommendations and further research works is presented.

1.5. Scope and Limitation of the Study

The scope of this study is developing a prototype knowledge base system for blood transfusion in health centers. There are a number of procedures to be followed in blood transfusion. First, blood has to be collected from donors then blood screening is held on and finally, there is a blood transfusion. The scope of this research is limited to develop a prototype KBS to assist experts in the area of blood transfusion. The phases of blood donation and screening were beyond the scope of this study due to limitation in time.

The types of knowledge to use for this study were, explicit knowledge sourced from, documents and manuals and tacit knowledge from domain experts and by observation of transfusion practices.

The study comprises the following knowledge base component; the knowledge base which consists of the rules and facts. Furthermore, the knowledge base system has an inference engine through which reasoning mechanism takes place by forward reasoning and SWI-prolog interface through which users can interact with the system. The system also comprises the explanation facilities through which users get further illustration when they interact with the system. Some of the explanation facilities used in this study are; the “what” explanation facility which users can ask the system when they need help during the gender identification, whether the patient is male or female, before proceeding to next steps. Moreover, “why” and why-not” explanation facilities are also used to help users when they interact with the system.

1.6. Significance of the Study

The primary beneficiaries of this research output are those experts who are involved in blood transfusion activities. The knowledge base will help experts in controlling and managing consistently during blood transfusion, to manage wrong type blood transfusion. Those inconsistencies created by human experts during blood transfusion will be solved if this system is applied.

The secondary beneficiaries of this research output are those patients who receive blood by transfusion. Those patients who need a blood transfusion can get the correct blood type for the right patient. That means dissimilar blood is not subjected to blood transfusion; instead, search for another donor takes place. Extra care takes place when urgent blood transfusion is administered. Hence, patients became free of threats of post-transfusion reaction due to wrong blood type transfusion.

1.7. Organization of the Thesis

This study is consisting of six chapters. The first chapter deals with the general introduction about background of blood transfusion and KBS, statement of the problem and justification to conduct the study. Furthermore, this chapter contains objective of the study, methodology to be

followed for the study, and the scope of the study as well as the testing procedure to be used to evaluate the system.

The second chapter contains conceptual and related literature works. The history of blood transfusion, the different types of blood types available and the blood transfusion procedures are discussed in this chapter. Moreover, this chapter contains detail discussion about knowledge base and its components, specific research works are reviewed regarding blood transfusion.

Chapter three contains the methodologies used in knowledge acquisition, tacit and explicit knowledge elicitation. In addition, knowledge modeling for each type of blood; for red blood cell, plasma, platelet whole blood type is done in this chapter.

Chapter four of this study is all about knowledge representation development. Discussion on how the inference engine and explanation facility works is done in this chapter.

Chapter five of this study consists of the general discussion on how the system works system works, testing and evaluation. Finally, chapter six, which is the last chapter of the study, discusses on the concluding remarks and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction to Blood Transfusion

Blood transfusion is a medical treatment that replaces blood lost through injury, surgery or disease. Blood transfusion is a common procedure in which recipients receive blood from blood donors when approved by physicians and clinical workers when required. A transfusion can also be made if a recipient's body cannot make blood properly because of an illness (Jason, Alan, Dean, and David, 2011).

Blood is composed of various components, such as white blood cells, red blood cells, platelets and plasma. Blood is transfused to patients either as a whole blood, with all its parts or as individual part, which is commonly known to be blood product transfusion (Cassandra, Leon, Krista, and Christopher, 2007).

Health care organizations are critical research areas for many health-related products. KBS can be developed to make life easy in the area for diagnosis and treatment of patients. In this study, KBS is developed to minimize errors faced during blood transfusion. Blood transfusion is full of risks out of which; transmission of infections, transfusion reactions and incorrect blood transfusion are the most common. In view of the risks of transfusion transmission of infections, the safest issue is not to administer blood transfusion, and this is applicable in developing countries (Cassandra, et al., 2007).

Moreover, transfusion is a treatment that adds whole blood cells or parts of blood called blood products such as, red blood cells, platelets and plasma, to one's own blood system. These blood products come from people who give blood that are donors or from one's own blood, which is autologous blood donation. Due to the fear of risk and lack of blood during blood transfusion, some people put their blood in blood bank to use their own blood a few weeks before they have surgery. If they need a transfusion during surgery, they can receive their own banked blood. This reduces the risk of disease and transfusion reaction from donated blood (Abdul-Nasser and

Mahmud, 2009). It seems a risk free in the case that receivers have a rare blood type group such as AB+, and it is difficult to obtain matched blood.

Blood transfusion is useful for taking advantages such as adequate regulatory steps for monitoring and evaluation of blood transfusion services and to take steps to eliminate abuse in blood banks. In medical practice, blood transfusion is used in several emergency and non-emergency conditions. Therefore, all health centers involved in management of such situations are required to keep updating of safe transfusion practices (Deshpande, 2003).

Knowledge base systems are effective in implementing systems, which require specific expertise in a specific field of study. In the case of medical area, specifically blood transfusion practices, knowledge-based transfusion advisor system can be design so that it does not cause delay during transfusion and requires minimum effort on the part of blood bank personnel, and still implements relatively complicated rules for approving or disapproving transfusion requests (Kent, Marc, and Robert, 1988).

Optimal blood use is clinically effective to the benefit of the patient and efficient use of donated human blood safely with no adverse reactions or infections due to transfusion (McClelland, and Pirie, 2010).

There are many rule based systems in use in the medical area, of which MYCIN is the dominant one, developed at Stanford University; it was applied within the domain of diagnosing bacterial infections of blood, which can be proven or disproved for blood transfusion (Sasikumar, 2007).

Effective blood transfusion is required to make life easy for patients as much as possible. This is achieved by giving care to the best evidence that is available such as room temperature, ABO cross-match compatibility and the need for indirect anti-globulin test. The main risk of blood transfusion is receiving a blood of the wrong blood ABO group. To ensure that patients in need of blood transfusion receive the right blood, the clinical staffs make careful checks before administering a blood transfusion such as taking a blood sample for cross-matching from donors and recipients (McClelland and Pirie, 2010) and (Dalton, Ippolito, Poncet, Rossini, 2005).

During blood transfusion, like any medical procedure, there are risks such as hemolytic reaction. It occurs when the patient's blood, and the transfused blood does not match. That is why precaution takes place to ensure that the donor blood is the correct match with that of the recipient before administering a blood transfusion (McClelland and Pirie, 2010).

2.2. History of Blood Transfusion

Blood transfusion is a useful and life-saving procedure and is becoming dominant since the discovery of antigens and antibodies specific for different blood types. The practice of blood transfusion from the blood circulation system of one individual to another for practical curative purposes was phenomena in the mid 1990s. It became a practical possibility during and shortly after the Second World War. The practicality of transfusion has paralleled and in some instances been the consequence of developments in other sciences (Phil, 2006).

Transfusion medicine is a specialized process concerned about the study of blood groups, along with the work of a blood bank to provide a transfusion service for blood and blood-related products. Across the world, blood products must be prescribed by a medical doctor who is licensed physician or surgeon in a similar way as medicines (Al Ghamdi, 2009).

Scientific exploration, discovery and experimentation changed the world more quickly and dramatically than ever before. The first human-to-human blood transfusion was performed, though the failure rate was high; this was not a surprising occurrence, since blood groups had not yet been discovered. However, that all changed in the years after Austrian Karl Landsteiner published his discovery of the three main human blood groups in 1901 four years before Albert Einstein published his Theory of Special Relativity. By the time of World War I, the value of blood typing had been grasped, and transfusion became an increasingly common and relatively simple medical procedure (Douglas, Stephen, and Alex, 2002). The founding of blood types and setting up of blood banks plays an important role towards the successful blood transfusion.

The need for blood transfusion arises when people lose a reasonable amount of blood due to several reasons such as emergency. It takes a few weeks for the body to make new blood to replace those lost. In this case, blood transfusion gives a massive advantage for the patient. Blood transfusion is the best way of replacing the blood rapidly. Blood transfusion is given to

replace blood lost during an operation or after an accident, to treat anemia which is a common disease caused by short production and supply of red blood cells (McClelland and Pirie, 2010).

2.3. Blood Types

According to Al Ghamdi (2009), there are four blood types, which are A, B, AB and O. Furthermore, every person's blood is either Rh-positive or Rh-negative. For example, if an individual has type A blood, it is either A positive or A negative. The blood used in a transfusion must work in the blood type; otherwise antibodies which are proteins in the blood will attack the new blood and cause a reaction. Blood type O negative blood is safe for almost everyone.

According to Aspirin (2010), about 40% percent of the population has type O blood. People who have this blood type are called universal donors. Type O negative blood is used for emergencies when there's no time to test a person's blood type. The RH factor or rhesus is a kind of protein found on red blood cells. Rh factor that is either positive or negative, in a sense the factor is either present or absent. Negative blood types and negative rh factors are genetically inherited classifications of antigen expressions on red blood cells.

People who have type AB blood are called universal recipients. This means they can get any type of blood and blood product. People who have Rh-positive blood can get Rh-positive or Rh-negative blood during blood transfusion. But if people have Rh-negative blood, they have to get only Rh-negative blood. Rh-negative blood is used for transfusion during emergencies when there's no time to test a person's Rh type (Aspirin, 2010). Many people who have surgery need blood transfusion, because they lose blood during their operations. People who have serious injuries also need blood transfusions to replace lost blood. Some people need blood transfusions because they have illnesses that prevent their bodies from properly making blood or parts of blood (Marco, Maria, La, Serenella, Roberto, 2011).

Before blood transfusion, a technician will test recipients' blood to find out what blood type the patient has and physicians prescribe a medicine to prevent an allergic reaction. Most people do not need to change their diets or activities before or after a blood transfusion.

When there is no longer enough time to test for blood type such as during emergency time, type O negative blood is used, that is because type O negative blood group is safe for almost everyone. After a blood transfusion, recipient's vital signs are checked if blood tests show reaction to the transfusion or not (Aspirin, 2010) and (Marco, et al., 2011).

Transfusion of blood involves numerous steps which need to be strictly controlled to ensure the safety of patients and to prevent or avoidable adverse events. These steps can be related to the patient, including assessment of physical condition and the need for blood under emergency or non-emergency conditions; verification of identity; informed consent to the transfusion and taking a blood sample for pre-transfusion testing; the blood product, including reserving products in the transfusion service; identification of the assigned unit; delivery to the clinical area and management of used and unused blood products (Koshio and Akiyama, 2009) and (Aspirin, 2010).

In whole blood transfusion, the blood from the donor must be compatible with that of the recipient. Blood is incompatible when certain factors in red blood cells and plasma differ in donor and recipient; when that occurs, agglutinins that are antibodies in the recipient's blood will bundle with the red blood cells of the donor's blood. The most frequent blood transfusion reactions are caused by substances from the ABO blood group system and the Rh factor system (Aspirin, 2010).

In the ABO system, group AB individuals are known as universal recipients, because they can accept A, B, AB, or O donor blood. Individuals with O blood type are also called universal donors, since their red cells are unlikely to be agglutinated by the blood of any other group. In the Rh factor system, agglutinins are not produced spontaneously in an individual but only in response to previous exposure to Rh antigens, as in some earlier transfusion. Transfusion reactions involving incompatibility eventually cause hemolysis, or disruption of recipient's cells. The resulting liberation of hemoglobin into the circulatory system, causing jaundice and kidney damage, can be deadly fatal (Aspirin, 2010) and (Marco, et al, 2011)

Any blood type, whether it is A, B, AB or O, stands for a certain type of protein found in blood cells. People who have the A protein had type A blood, those who have the B protein have type

B blood, and those who have the A and B protein proteins have type AB blood. People with neither protein have type O blood (Socha and Moor-Jankowski, 2005). Another protein found on some red blood cells is the Rh, or Rhesus which is a protein. People with this protein are called Rh positive. Those without this protein are Rh negative. The plus (+) and minus (-) signs are used to indicate positive and negative, hence absence or presence of that particular protein (Koshio and Akiyama, 2009).

Blood transfusion has scientific standards in that it should be issued from the blood bank along with the blood cross matching approved by respected blood transfusion experts. The cross-matching of blood testing is done by mixing small amount of recipient's blood with the donor's blood. There is cross matching form which incorporates patient's name, age, sex, identification number, ABO and Rh factor (Sujatha, 2007).

There are cases where blood transfusion can be issued before completion of blood type and RH factor cross matching test takes place in cases where; the clinical condition of the patient requires urgent blood transfusion. In such a case, recipients whose ABO and Rh (D) type is not known should receive a blood type of group O negative Rh (D) if available. Furthermore, ABO group compatible is universally acceptable for blood transfusion and RH negative patients are required to get RH negative blood especially women in child bearing age group (Tripathi, 2011). Medical experts in the area of blood transfusion are recommending three strategies for clinical blood transfusion process, which are pre-transfusion, transfusion and post-transfusion phases (Marco, et al., 2011).

2.4. Blood Transfusion Procedures and Life Cycle

Blood transfusion takes on multifaceted series of activities with a correspondingly high prone to error. To ensure the right patient receives the right blood, there must be strict checking procedures in place at each stage (Berry and Hart, 1993). At each procedure there is a control mechanism which involves ensures the safety of patients and prevents adverse events. At each procedure emphasis is given to the patient with respect to the need for blood under emergency or non-emergency conditions, and taking a blood sample for pre-transfusion testing. With respect to

the blood product, reserving products and management of used and unused blood products is held on. In general, there are six phases in a blood transfusion, which are described as follows.

Assess Patient and Decide Transfusion

This is an essential part of decision on transfusion. Moreover, assess clinical condition, use clinical guidelines inform patient and obtain consent and record the decision and rationale.

Order the Blood Component

The Essentials of ordering blood component is done by identify the patient correctly, take blood sample and correctly label the tube which contains the sample, complete the request, take note of special transfusion requirements, send the sample and request form to the blood bank, communicate with the blood bank if blood is required urgently.

Pre-transfusion Testing

Essentials of pre-transfusion testing, determine patient's ABO type and RH factor detect clinically significant, red cell antibodies, select and cross-match, red cell units, apply the compatibility labels.

Deliver the Blood Component

Essentials of delivery to clinical area, component labeling must match patient identifiers, record removal of unit from storage location, deliver to appropriate person in clinical area, maintain correct storage conditions until transfusion.

Administer the Blood Component

Essentials of administering blood components, identify the patient correctly, ensure there is a written instruction to transfuse, record pre-transfusion vital signs, check (control) patient's blood group if this, normal procedure, repeat check of patient identification against, component label/documentation, inspect component unit/check expiry date, set rate of transfusion according to instructions and complete all documentation.

Monitor the Patient

Essentials of monitoring transfused patient; monitor patient's vital signs regularly; recognize, diagnose, respond to adverse event; record outcome of transfusion and assess need for further transfusion. The haemovigilance systems take place which is the use of a measurement system to record unwanted outcomes of transfusion.

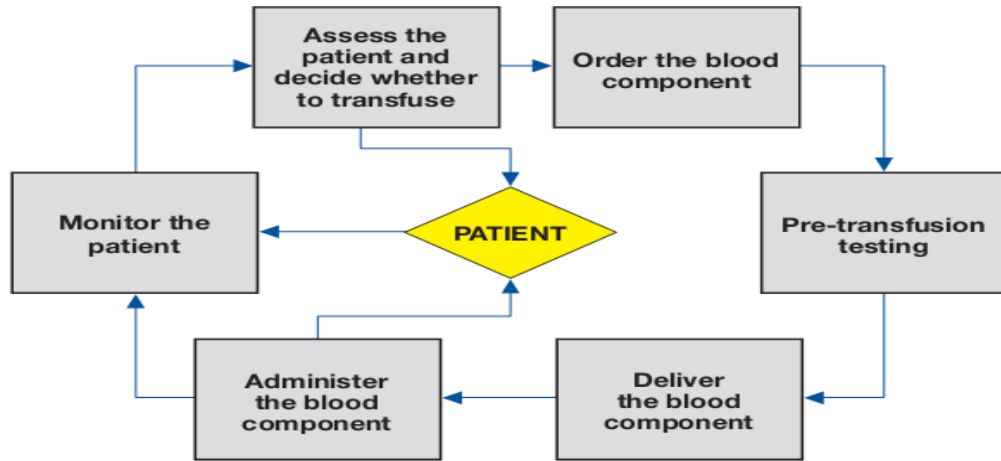


Figure 2.1: Blood transfusion procedures

Source: McClelland D., and Pirie F., (2010), Manual of Optimal Blood Use, Support for safe, clinically effective and efficient use of blood in Europe

2.5. Knowledge Based Systems

Artificial intelligence is the study of creating machines that can perform an action which requires human intelligence. It deals with the principles and techniques that enable computers to tackle problems that have previously been thought possible only for humans to solve. It is sub field of computer science, concerned with symbolic reasoning and problem solving. The main concern of artificial intelligence is to enable computers to behave like human beings and imitate the reasoning power of humans to do tasks that necessitate human being's intelligence by making machines smarter, which is a primary goal, understand what intelligence is all about make machines more intelligent and useful (Spackman and Connelly, 1987) and (Forsythe, 1993).

Knowledge based systems is a branch of artificial intelligence that makes extensive use of specialized knowledge to solve real world problems which normally would require a specialized human expert. KBS system is an intelligent computer program that uses knowledge and reasoning procedures. Designing and constructing knowledge based system involves extracting the relevant knowledge of practical problem domain during knowledge acquisition (Tomas, 2004).

KBS is one branch of AI, which is growing research area that uses artificial intelligence and expert system techniques in problem solving processes. It incorporates a store or database for facts of expert's knowledge with blend, and linkages designed to facilitate its retrieval in response to specific queries and transfer expertise from one domain of knowledge to another. Nowadays, every business in today's competitive world is full of uncertainty and risk. Managing and satisfying customers with quality product and services have become a trivial challenge. In this situation, the knowledge-based system is a wise choice to support services especially in areas where scarce and deep expert knowledge is required (Cassandra, et al, 2007). Blood transfusion is very technical and demands specific and deep expertise, where there is also scarce of professionals in the area.

Moreover, knowledge-based systems are computer-based systems that use information to provide relevant advice and problem solutions within a specific domain. Knowledge based systems enable expert knowledge to be accessed all the time when the system is on, even when an expert is unavailable. KBS gives a privilege to provide a means to preserve information when the expert retires (Schipper, 2008).

Knowledge plays a great role in KBS development in that it is a subjective interpretation of information in effort to recognize the applications and approach to act upon in the mind of perceiver. It attaches purpose and competence to information, resulting in the potential to generate action (Priti and Rajendra, 2010).

Knowledge-Based System (KBS) is one major part of the family of Artificial intelligence groups. It is designed to simulate problem solving behavior of an expert in a certain domain or discipline.

A knowledge base (KB) is a centralized repository of information. It is used to optimize information collection, organization and retrieval. It is dynamic resources that have the capacity to learn as part of artificial intelligence (Dlodlolo, Hanter, Cele, Botha, and Metelerkamp, 2009).

AI programs that achieve expert level competence in solving problems in task areas by bringing to bear a body of knowledge about specific tasks are called knowledge based systems (Priti, Rajendra, 2010).

Nowadays, the society and industry in general are becoming more of knowledge oriented and relying on different applications of knowledge based systems. According to Sasikumar (2007), Knowledge base systems have the capability to act as an expert on demand, anytime and anywhere.

Knowledge Base System can also be economical by leveraging expert, allowing users to function at higher level and promoting consistency. One of the major privileges of a knowledge base system can be acting as a productive tool, having knowledge of more than one expert for long period of time by generating knowledge from data and/or facts by applying rules (Sasikumar, 2007).

There are several definitions of knowledge based systems (KBS). A KBS is constructed to input, manipulate, edit, store and execute existing facts extracted from sources. They are systems that use knowledge-based techniques to support human decision making, learning and action (Dlodlolo, et al, 2009).

KBS is defined as computer systems that are programmed to imitate human problem-solving by referencing databases of knowledge on a particular subject. Expert systems are a type of KBS, which is computer model of human expertise in a specific domain of work. They are capable of offering advice and decision-support related to specific problem-solving in a well-defined knowledge domain. KBS acts like an expert consultant, asking for information, applying this information to the rules it has learned, and drawing conclusions (Soumeiya, 1999).

Knowledge-based systems have several advantages over human experts or natural intelligent systems. To mention some of the major advantages; knowledge-based systems provide efficient documentation of the important knowledge in a secured and reliable way. Moreover, Knowledge-based systems solve unstructured, large and complex problems in a quick and intelligent fashion and provide justification for the decision suggested and KBS offers more than one type of expert knowledge in an integrated fashion. Furthermore, knowledge-based systems are able to infer or create new knowledge and learn from cases or data instead of just referring the stored content, especially in the case of a case based reasoning (Cassandra, et al., 2007).

2.6. Structure of Knowledge Base Systems

Knowledge based system consists of at least four components, which are the knowledge base system that contains the experts' knowledge which are the facts, rules and heuristics or experience. The inference engine which contains the reasoning and problem solving strategies; the working memory that holds data about the particular situation the system is evaluating and records the steps of the reasoning sequence. The user interface is used to communicate with the expert system by users (Schipper, 2008).

KBS has the following commonly used components, techniques for acquiring knowledge, ways of representing knowledge internally, because computers are good at representing numbers, words, even maps, but knowledge is potentially much more difficult, search procedures for working with the internally stored knowledge, inference mechanisms for deducing solutions to problems from stored knowledge.

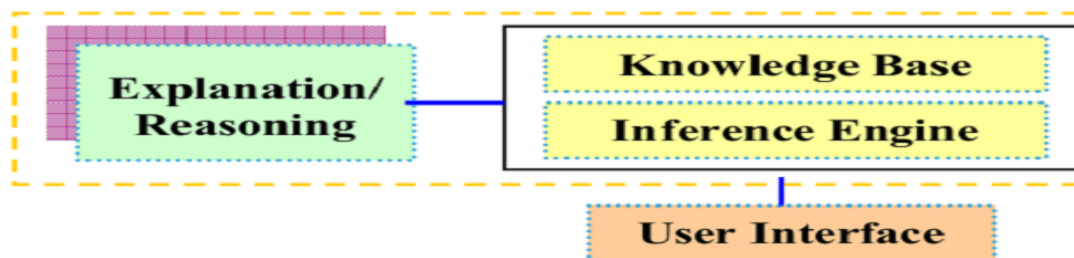


Figure 2.2: Structure of Knowledge Based System

(Source: Priti and Rajendra, 2010). Advanced Knowledge Based Systems: Model, Applications & Research)

2.6.1. Knowledge Base

Knowledge base is a collection of facts, rules, and procedures organized into schemas. It is the assembly of all the information and knowledge about a specific field of interest. Knowledge base is the permanent knowledge of an expert system is stored in a knowledge base. It contains the information that the expert system uses to take decisions. This information represents expertise gained from top experts in the field. The knowledge base generally holds the knowledge which is useful for understanding, formulating and for solving problems. It is a warehouse of the domain-specific knowledge captured from the human expert during knowledge acquisition (Tripathi, 2011) and (Turban, Sharda, and Delen, 2010).

This knowledge comes in the form of facts and rules. Facts are minimal elements of the knowledge which must be identified before anything else. Rules consist of IF-THEN statements, where a given set of conditions will lead to a specified set of results. If a condition is true, then an action takes place. Knowledge base works by taking questions and problems from users as an input and results in alternate solutions and answers through the inference mechanism (Turban, et al, 2010).

Production Rules

The general formalism of rule based systems is shown as IF <condition> THEN <action>, which is dominantly known as a production rule in the literature. For instance; IF X, THEN Y, where X is a condition and Y is an action. Condition X can be a composite condition consisting of, say, a conjunction of premises X1, X2 ..., Xn. A rule-based system is a set of "if-then" statements that uses a set of assertions, to which rules on how to act upon those assertions are created.

Production rules have privilege over the other rules in that, rules are independent and modular. Rule-based reasoning requires that the problem solver take into account all the domain rules. However, in many real-life situations the problem solver is not capable of doing that, under the pressure of time, as the number of rules required for solving a problem may be unmanageably large (Eshach and Bitterman, 2003).

Frames

Frames deal with data structure of objects. Frame allows hierarchical knowledge structure and is suitable to represent knowledge about concepts and their relationship. A single frame incorporates name of objects and property or states which are used to indicate some feature of certain objects.

Frame Desktop computer

Hard disk drive: 0, 1, 3

Optical disk drive: 0, 1

Power supply: 0, 1

Motherboard (1) which is a default value for most computers

Then, the slot values can be inherited by other related frames.

Frame My_Desktop_computer

Isa: Table

Hard Disk Drive: 1

Optical Disk drive: 2

Motherboard: 1

Decision Tables

The decision table technique, with its ability to check a given specification for completeness, consistency and correctness, has been recognized as a very inviting formalism in a variety of areas. Common application domains include: program structuring, manual decision making, systems analysis and design, representation of complex texts, verification and validation of knowledge bases, knowledge acquisition. Nevertheless, this technique is criticized from the reason that it is not flexible and friendliness. Moreover, it contains several routine actions, which are quite time-consuming.

Propositional Logic

Propositional Logic is concerned with propositions and their interrelationships. In Propositional logic, there are two types of sentences simple sentences and compound sentences. It allows you to evaluate the validity of compound statements given the validity of its atomic components.

For example:

I like soccer or I like volley ball ($P \vee Q$).

If I like soccer then I like volley ball ($P \rightarrow Q$).

Do I like volley ball (Q)?

The first two sentences are facts and the third is a query, which can be convinced from the facts given.

Predicate Logic

In this case, knowledge is represented as a symbol structure that features knowledge about objects, concepts, rules and strategies.

For example:

“Black” represents any black color

“My-hair” represents hair

“Black (My-hair)” represents the fact that my hair is black color.

Semantic Networks

These are multi-directed graphs used to represent conceptual knowledge, which is described in nodes and links, which depict hierarchical relationship between objects. The nodes are made up of circles to represent objects, which are any form of objects such as physical and conceptual objects and their description about these objects. It is argued that this form of representation is closer to the way humans’ structure knowledge by building mental links between things.

In fact, the three distinctive roles correspond to what is known in natural language grammar as subjective (the object doing the action, in this case John), objective (the object to which the

action is being done, in this case the book) and dative (the recipient of the action, in this case Mary). These distinct roles of objects in a sentence are known as cases.

For example, if we take the act of give and take, it has three participants: the donor, the recipient, and the gift, so the semantic net representing the sentence is described graphically as follows.

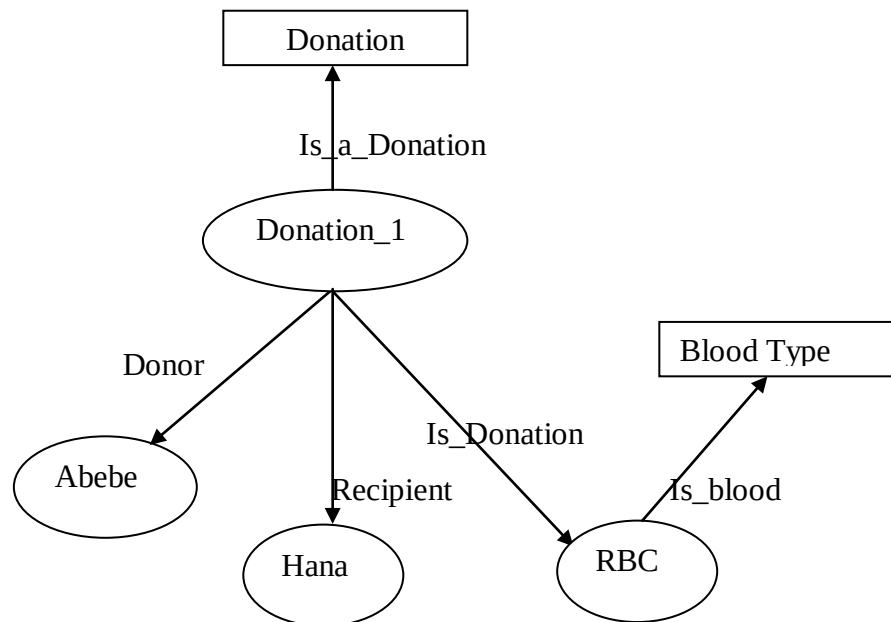


Figure 2.3: Semantic Net Examples

Neural Network

Artificial Neural Network (ANN) is a non-linear mathematical or computational model for information processing. In most cases, it is an adaptive system that changes its structure based on external or internal information that flows through the network. It also addresses issues by adapting previously successful solutions to similar problems (Turban, Aronson, and Liang, 2007).

People often take decisions based on partial, incomplete, and inexact information, which are created in the rapidly changing environments. In such cases, decision-makers use their experiences by recalling related cases hence learn and do with similar new situations for which exact models are unavailable. This is dominantly a machine learning which approaches to solve problems using artificial neural networks (ANN) and case-based reasoning as primary tools (Turban, et al., 2007).

2.6.2. Inference Engine

Inference is the process of chaining multiple rules together based on available data in the knowledge base. The inference engines are applicable in answering and solving complex queries in order to infer possible answers. The purpose of the inference engine is to seek information and form relationships from the knowledge base and provide answers. The inference engine matches facts in the working memory against rules in the rule base, and it determines which rules are applicable according to the reasoning method adopted by the engine (Turban, et al., 2007).

It determines which rules will be applied to a given question, and in what order, by using information in the knowledge base. The inference engine drives the system by drawing an inference from relating user-supplied facts to a knowledge-base rule and then proceeding to the next fact and rule combination (Berry and Hart, 1993), and (Turban, et al., 2010).

In an inference mechanism when all the rule's hypotheses or the if parts are satisfied, a rule said to be fired, in a sense inference engine checks every rule in the knowledge base in a forward or backward direction to find rules, which continue until no more rules can fire, or until a goal is achieved (Turban, et al, 2010).

Backward Chaining

In artificial intelligence (AI) systems, backward chaining refers to a scenario where the AI has been provided with a specific goal and must work backwards to figure out how to achieve the set goal. To do this, the AI would look back through the rule-based system to find actions in the "then" rules. It is a goal-driven approach in a rule-based knowledge based system and is appropriate for problem solving (Turban, et al, 2007). It begins working with the action clause of a rule and works backward through a chain of rules in an attempt to find a verifiable set of condition clauses which recovers prolog from bad choice of alternate solutions. For example, the following set of rules reflects this type of reasoning in KBS.

For example: IF A and B THEN C

Else D

In this case, “if” means when the condition is true (“IF A and B is true”), the “then” means “take action C” and the “else” means "when the condition is not true take action D.

RULE1: If credit_score is less than 650 AND

Age is less than 35

THEN Risk is high

RULE 2:

IF robbery is TRUE

AND

suspect witness identification is TRUE

AND

suspect physical evidence is TRUE

AND

suspect lacks alibi is TRUE

THEN

probable cause is TRUE

ELSE

round up usual suspects

The problem to be solved here can be to find out if C is true. To establish C is which the consequent of rule 1, the inference engine tests if the antecedent is true. The antecedent involves the establishment of the truth of A and B, then two sub-goal problems are now set up, that is prove the truth of A and B, then only when A and B are proven true, C is also true (Raman, and Prasad, 1987). The inference engine attempts to match the assumed (hypothesized) conclusion, the goal or sub-goal state, with the conclusion (THEN) part of the rule. If such a rule is found, its premise becomes the new sub-goal. In a knowledge base system with few possible goal states, this is a good strategy to pursue.

If a hypothesized goal state cannot be supported by the premises, the system will attempt to prove another goal state. Thus, possible conclusions are reviewed until a goal state that can be supported by the premises is encountered.

Backward chaining is best suited for applications in which the possible conclusions are limited in number and well defined. Classification or diagnosis type systems, in which each of several possible conclusions can be checked to see if it is supported by the data, are typical applications.

Forward Chaining

In AI systems, forward chaining refers to a scenario where the AI has been provided with a specific problem which works forward to figure out how to solve the set problem. To do this, the AI would look back through the rule-based system to find the "if" rules and determine which rules to use.

Forward chaining is a data-driven search in rule-based KBSs. If the premise clauses match the situation, then the process attempts to assert the conclusion (Turban, et al, 2010).

The inference process moves from the facts of the case to a goal or conclusion. The strategy is thus driven by the facts available in the working memory and by the premises that can be satisfied. The inference engine attempts to match the condition (IF) part of each rule in the knowledge base with the facts currently available in the working memory. If several rules match, a conflict resolution procedure is invoked; for example, the lowest-numbered rule that adds new information to the working memory is fired. The conclusion of the firing rule is added to the working memory (Turban, et al, 2010).

Forward-chaining systems are commonly used to solve more open-ended problems of a design or planning nature such as, establishing the configuration of a complex product. It works by adding the conclusion the knowledge base until query is found and it is time taken, because it may do various works which are irrelevant to the goal.

The choice from backward chaining and forward chaining depends on how domain experts solve the problems. If the domain experts solves a problem by first collecting data and infer a solution from this data, then it is forward chaining. But if the domain expert starts hypothetical solution and then attempts to find facts to prove the hypothesis, then it is a backward chaining (Turban, et al., 2010).

2.6.3. Knowledge Acquisition

The extraction and formulation of knowledge derived from various sources, especially from experts and other sources of knowledge. Knowledge acquisition in knowledge based systems development involves elicitation and representation of the appropriate knowledge from its

sources such as human experts, textbooks, multimedia documents, databases, different research papers, yellow pages and from the web in general. This is a process by which KBS developers use it to determine where in the organization the knowledge exists, how to capture and use it in the prototyping phase. Approaches of capturing knowledge takes many forms and are evolve over time. New facts and rules can be added to the knowledge base by using the knowledge acquisition sub-system (Rhem, 2002).

Knowledge acquisition includes the elicitation, collection, analysis, modeling and validation of knowledge for knowledge engineering in knowledge management researches. Some of the most important issues in knowledge acquisition are; most knowledge is in the heads of experts that experts have vast amounts of knowledge in the form of tacit knowledge; hence they do not know all that they know and use that is because tacit knowledge is hard and impossible to fully describe. Moreover, experts are very busy and valuable people, because of such reasons design and implementation of KBS is require in certain domain areas (Rusel and Norvig, 2003).

Typical use of knowledge acquisition techniques are; conduct an initial interview with domain experts in order to elicit what knowledge is going to be acquire, determine what purpose the acquired knowledge is, gain some understanding of key terminologies build a relationship with the experts throughout the research duration to have more complete KBS.

2.6.4. Explanation Subsystem

This is an important component of a knowledge based systems that can explain and justify the system's reasoning and justify its conclusions. Another unique feature of a knowledge base system is; its ability to explain its advice or recommendations and even to justify why a certain action was recommended. The explanation subsystem enables the knowledge base system to examine its own reasoning and explain its operations. The ability to trace responsibility for conclusions to their sources is crucial, both in the transfer of expertise and in problem solving (Turban, et al., 2010) and (Clarke, O'Moore, Smeets., 1994)

The explanation facility explains how the system arrived at the recommendation. Depending on the tool used to implement the knowledge base system, the explanation may be either in a natural

language or simply a listing of rule numbers. Explanation is essential in knowledge-based systems used for training and evaluation.

The WHY Explanation

This explanation session is asked by users why a fact is requested by the system. The system asks the user for an input continuously and the user asks for the system why was the question asked by the system before answering the system's question.

The HOW Explanation

This explanation mainly uses to determine how a certain conclusion or recommendation was reached. Users raise this explanation at the end of certain conclusion or recommendation to know exactly how that specific conclusion was reached. It follows a step-by-step approach to reach the final answer.

The WHYNOT Explanation

Such a question is raised if expected results were not reached. Users in this case are interested to know why certain request was unsuccessful.

2.6.5. The Human Element of knowledge Based Systems

Mainly there are three human elements or stakeholders involved throughout the development and use of knowledge based systems. These are:

- **Domain expert-** These are individuals who involve in solving problems regarding a certain profession and are considered as knowledge providers in a certain field of study; such as domain experts in the field of health, agriculture, education and service areas. These are individuals with special knowledge, judgment, experience and methods to give advice and solve problems.
- **Knowledge Engineer-** Helps the experts in structuring the problem area by interpreting and integrating human answers to questions, drawing analogies, posing counter examples, and enlightening conceptual difficulties. These people involves in identifying problems which can be solved by applying knowledge based systems problem solving methods, extract knowledge from its sources, model and codify so that it can be used by end users and knowledge workers. The primary goal of knowledge engineer is to help

experts articulate how they do, what they do and to document this knowledge in a reusable form.

- **User-** individuals who are in need of consulting of knowledge based systems to perform their day-to-day activities mainly dealing with decision making. Such a people can be system analyst, system builders and supporting staff.

2.6.6. User Interface

User interface is a component that facilitates interaction between the user and the knowledge base system. But, it is not considered as a part of the main knowledge base system, however, it is now widely accepted that the user interface can make a critical difference in the perceived utility of a system regardless of the system's performance (Cassandra, et al., 2007).

User interface includes a sophisticated graphical user interface (GUI) which is a user-friendly interface that allows secure and confidential access to information. It has a short response time (timely information) is accessible from many places which includes a reliable access procedure (Turban, et al, 2007).

User Interface is basically the most important component of KBS, which deals with human-computer, which works through menus or graphical and visual elements and natural language. Mainly, the user interface allows users to specify their problems via form filling, or even natural language dialog to get a specified solution for the problems by presenting users with the reasoning used to derive its solution (Cassandra, et al., 2007).

A good user interface can matter and make poor knowledge based system to look as if it is interesting or a poor user interface can also negatively affect a good knowledge base system.

2.7. Inference with Uncertainty

Uncertainty is represented as a degree of belief, which expresses the measure of belief. Tasks which require some intelligence behavior fall in some degree of uncertainty. There are also peculiar factors which express belief about an event based on evidence or the expert's assessment which has 1.0 or 100% absolute truth and complete confidence; and 0% certain falsehood (Turban, Sharda, and Delen, 2010). It is possible to express several certain factors in a single rule by connecting using logical operators. It is possible to manipulate degrees of belief while using knowledge-based systems to get the level of certainty.

Example of certain factors is:

If inflation is high, with a CF=40% AND

Unemployment rate is above 8, with CF= 80% AND

Bond price declines, with CF= 100%

THEN stock price declines

The confidence factor of the cases in this single rule is taking the minimum of the values, because of the AND logical connector. On the other hand, if the above rule is connected using the OR operator, then it takes the maximum value.

2.8. Knowledge Based Systems and Conventional Programs

KBS programs and the conventional or traditional programs have their own distinguishing features. The major distinguishing features of KBS programs as compared to conventional programming language is; the simplicity, use of few rules and memory management capabilities. KBS programs work by instantiate rules when activated by conditions in a set of facts. Of all possible activations, some set is selected and the statements belonging to those rules execute. KBS programs hold knowledge in the form of declarative or procedural. While declarative knowledge is stored as a set of facts about objects, events, which can easily be modified added to or deleted; procedural knowledge is stored as a set of procedures which themselves determine when they are executed (Tomas, 2004).

Conventional programs use data instead of knowledge; they are algorithmic and iterative, not inferential. Moreover, conventional programs use more of equations and numbers instead of concepts and are appropriate for problems with only a single solution (Place, Truchaud, Ozawa, Pardue, and Schnipelsky, 1995).

2.9. Application of Knowledge Based Systems

There are several KBS applications; broadly knowledge-based system applications can be divided into two major categories. These are, pure and applied knowledge-based systems application. Pure application includes researches contributing in knowledge-based systems and AI development techniques such as knowledge acquisition, knowledge representation, models of automated knowledge-based systems development such as knowledge engineering approaches, models and CASE tools for KBS, knowledge discovery and knowledge management types of tools (Priti and Rajendra, 2010).

2.9.1. Related Research Works to Blood Transfusion

There are various knowledge-based systems developed by different scholars all over the world. Expert systems and decision support systems were dominant in 1970s followed by knowledge-based systems in the 1980s. Mainly, KBS is applicable in problem solving areas such as planning, scheduling, troubleshooting, diagnosing and designing of specific area systems, interpretation systems, prediction systems, repair systems, monitoring systems, debugging systems, instruction systems and controlling systems. Here are some examples of related KBS research works in blood transfusion.

(Knowledge Acquisition Environment for the Design of a Decision Support System: Application in Blood Transfusion (Soumeya et al, 1999).

This system was developed by Soumeya (1999), to help medical experts in the area of blood transfusion. The goal of this system was to support the physician in his or her decision to transfuse or not a patient and to choose the right blood product to be prescribed to those who are in need of blood transfusion. As a development tool, rule problem solving method, conditions-actions, is used and a tool is developed to acquire new rules, according to a pre-established model based on the domain ontology. These rules are automatically integrated in the knowledge base.

According to this system a typical rule for blood transfusion is held as follows:

IF Condition (Sickle Cell anemia) present and

Condition (Multiple Organ Failure) present and

Condition (Hemoglobin<10) present and

Condition (Hemoglobin>=8) present

THEN action (Erythrocyte Transfusion)

An Intelligent System for Improving Performance of Blood Donation

(Wen-Chen and Bor-Wen, 2011)

This system was developed by Wen-Chen and Bor-Wen (2011) in Taiwan, Graduate School of Industry Engineering and Management, National Yunlin University of Science and Technology. The main objective of this system was to determine the disparities in blood donation behavior among the present donors and predict their intentions towards donation to understand the problems and to increase voluntary blood donation services by retaining blood donors.

The system mainly concerns on how guarded and adequate blood can be collected from blood donors to secure life of patients who are in need of blood transfusion. As per to the system blood donation in Taiwan was decreasing over time. So the system was also required in how blood donors can be retained, hence patients can receive sufficient and healthy blood provided that healthy and volunteer blood donors are retained. In this work, knowledge-based system application was used to support the decision of blood transfusion. The performance of the system was 78.3% in determining the disparities in blood donation behavior of donors and predict.

The Transfusion Advisor: A Knowledge Based System for the Blood Bank

(Kent S., Marc J. C., and Robert B. 1988)

This system was developed having an objective to facilitate the review of transfusion requests in hospital blood bank. The system works by drawing conclusion about twelve hemostatic disorders

and critiques to the appropriateness of the use of frozen plasma. A LISP programming language was used as a development tool.

The evaluation of the system showed closer agreement of the KBS with the domain experts than with the clinicians administering the transfusion. The system had registered a positive performance of 67% in facilitating transfusion requests in hospital blood banks.

In this study, the main objective is to design a knowledge based system to assist domain experts. The system has designed to enhance effective blood transfusion decision making. For patients in need of blood transfusion, only compatible blood types are expected to transfuse with the help of this system.

2.10. Representing Knowledge

Knowledge representation deals with formalizing and organizing the knowledge. Several knowledge representational models have been used to construct knowledge-based systems, including symbolic methods, such as simple decision trees, statistical and/or probabilistic methods, and rule-based and frame or descriptive logic based expert systems (Lifschitz, Morgenstern, and Plaisted, 2007).

Knowledge representation deals with formalizing and organizing the knowledge. The widely used representation is the production rule. A rule consists of an IF part and a THEN part which is the condition and an action (McClelland and Pirie, 2010), the IF part lists a set of conditions in some logical combination. The piece of knowledge represented by the production rule is relevant to the line of reasoning being developed if the IF part of the rule is satisfied; consequently, the THEN part can be concluded, or its problem solving action taken. Expert systems whose knowledge is represented in rule form are called rule based systems.

The knowledge base of a KBS contains both factual and heuristic knowledge. Knowledge representation is the method used to organize the knowledge in the knowledge base. Knowledge bases must represent notions as actions to be taken under circumstances, causality, time, dependencies, goals, and other higher-level concepts (Aronson and Turban, 2007). Several

methods of rule based knowledge representation methods are available. The two dominant rule based knowledge representation methods are described below.

2.10.1. Knowledge Representation in Frame-Based Systems

Frames are an application of the object-oriented approach to knowledge-based systems in which knowledge is represented as a series of frames, which contains a typical knowledge about a concept or an object. These knowledge representation methods are employed for building powerful knowledge-based systems. A frame specifies the attributes of a complex object and frames for various object types have specified relationships. A frame contains both descriptions of attributes and procedural details and represents knowledge about objects in a real world.

2.10.2. Knowledge Representation in Production Rules

Production rules follow particular type of reasoning which uses "if-then-else" rule statements. Rules are simply patterns and an inference engine searches for patterns in the rules that match patterns in the data. Production rules are the most common method of knowledge representation used in business. Rule-based expert systems are expert systems in which the knowledge is represented by production rules. In a rule based system, much of the knowledge is represented as rules, that is, as conditional sentences relating statements of facts with one another. Modus ponens is the primary rule of inference by which a system adds new facts to a growing data base (Bruce and Rechard, 1982).

According to Aronson and Turban (2007), production rule is one widely used knowledge representation method. A rule consists of an IF part and a THEN part which is the condition and action; and the IF part lists a set of conditions in some logical combination. The piece of knowledge represented by the production rule is relevant to the line of reasoning being developed if the IF part of the rule is satisfied; consequently, the THEN part can be concluded, or its problem-solving action taken. Knowledge based systems whose knowledge is represented in rule form are called rule-based systems.

Unlike to the rule based reasoning, a case-based reasoning uses past experience as the domain knowledge and can often provide a reasonable solution, through appropriate adaptation, to these

types of problems by measuring the degree of similarity of the previous and current cases (Aamodt and Plaza, 1994).

2.11. Testing and Evaluation of the KBS

Evaluating a knowledge base system requires more elaborate methodology than a simple iterative test and refines cycle. At the design stage an adequate knowledge base structure is required to allow focused modification of the knowledge base when errors are discovered.

Evaluation of a system by domain experts is helpful to determine the quality and interactive feature of the knowledge based system. Moreover, verification of a knowledge base system is to demonstrate the consistency, completeness and correctness of the knowledge base system so as to make users confident enough in using it. According to Berry and Hart (1993), the success of a system is not only about the system matching user needs and supporting users in their tasks, but also deals with the match between the system and the social and political factors within the host organization. This is performed by give emphasis to the usability, through interviews, questionnaires, formal observation while users interact with the system, system logging, simple testing and experiments.

Furthermore, determine a system whether the implemented KBS completely satisfies its specifications specified in the scope of the study area. According to Hope and Meseguer (1993), and (Clarke., et al., 1994), checking a system against the well-defined objectives of a KBS with respect to its specification in particular KBS components such as; knowledge base content, inference engine and the user interface is taken into consideration for evaluation.

Analysis of KBS evaluation and assessment helps to identify the main points in the evaluation and assessment of the knowledge base system. The important features of knowledge base system evaluation is the absence of a well-defined and well-structured set of requirements at the beginning of the development process, continuous changes in the requirements during the whole development phase is required to make the system full-fledged KBS.

CHAPTER THREE

3.1. KNOWLEDGE ACQUISITION

Knowledge engineering is all about build, maintain and development of knowledge based systems in the field of artificial intelligence. The knowledge acquisition process starts with Elicitation. Methods such as structured interviews are used for acquiring informal descriptions of the knowledge about the specific domain and the problem solving process itself. The resulting knowledge expressed in natural language is stored in knowledge protocols (Rudi, Richard, and Dieter, 1998).

Knowledge engineering has phases such as elicitation, representation, design, and implementation (Ferruccio, Nicola, and Paolo, 2010). Each of these activities deals with different aspects of the system development. It is the result of the knowledge acquisition which contains all the functional requirements of the intended knowledge base system.

There are two main views to knowledge engineering; these are the transfer view, this is the traditional view. In this view, the assumption is to apply conventional knowledge engineering techniques to transfer human knowledge into artificial intelligence systems. The other view is modeling view; this is also the alternative view. In this view, the knowledge engineer attempts to model the knowledge and problem solving techniques of the domain expert into the artificial intelligence system (Cabrerizo, P´erez, and Herrera-Viedma, 2009). There a number of KBS development tools, out of which typical programming languages such as java and framework like .NET can be used in KBS development. KBS shell is also a readymade utility of self learning, explanation and inference tool.

Prolog is a logic programming declarative general purpose fifth generation artificial intelligence language. The program logic is expressed in terms of relations, and execution is triggered by running queries over these relations. According to Priti, and Rajendra (2010), prolog language was first conceived by a group around Alain Colmerauer in Marseille, France, in the early 1970s. Moreover, Prolog or program logic is expressed in terms of relations, and a computation is initiated by running a query over these relations.

In this study, the knowledge engineering which is mainly knowledge-based system development has been done by searching knowledge from its sources source, designs and selects development tools which is prolog programming, then develop, testing checking against domain expert specification in the area of blood and blood product transfusion. The reason behind using prolog code for the system development is that, prolog is more expressive than other conventional programming languages. This is due to three major features of prolog language, which supports rule-based programming and has additional feature which is built-in pattern matching, the backtracking execution (Dennis, 2000).

The rule-based programming allows the program code to be written in a form which is more declarative than procedural. This is made possible by the built-in pattern matching and backtracking which automatically provide for the flow of control in the program.

Knowledge acquisition is a key task of knowledge engineering and has got several working definitions by several researchers in the area of AI and knowledge base development. According to Watcharachai and Walita (2009), and Cabrerizo, et al., (2009), knowledge acquisition is a method of obtaining, systematizing and studying knowledge. Knowledge acquisition involves the acquisition of knowledge from human experts, books, documents, or computer files. The knowledge may be specific to the problem domain or to the problem-solving procedures; it may be general knowledge which is knowledge about business or else meta-knowledge that is knowledge about knowledge, which is information about how experts use their knowledge to solve problems and about problem-solving procedures in general.

3.2. Knowledge Elicitation Methods

Many knowledge elicitation methods have been used to obtain the knowledge required to solve problems. These methods can be classified in many ways. One common knowledge elicitation method is how to directly obtain knowledge from the domain expert. Direct methods involve directly questioning a domain expert on how they do their job. In order for these methods to be successful, the domain expert has to be reasonably articulate and willing to share their knowledge. The knowledge extracted has to be easily expressed by the knowledge engineer,

which is often difficult task. Indirect methods are used in order to obtain knowledge that cannot be easily expressed directly such as observation.

There are a number of factors that influence the choice of knowledge elicitation method, some of which are the amount of domain knowledge required by the knowledge engineer and the effort required to analyze the data.

Many methods of knowledge elicitation can fit into more than one category of knowledge such as tacit and explicit and are applicable in collecting knowledge. But for the sake of this study, direct methods such as interview and document analysis and indirect methods such observation are employed.

3.2.1. Tacit Knowledge Elicitation

There are contextual complexities in the area of knowledge management and knowledge based systems as a result of the nature of knowledge based resources which are dominantly becoming the basis for competitive advantage in organizations (Garcia-Perez and Mitra, 2007). Procedures are also methods that can be used to determine the steps followed to complete a task during blood transfusion.

According to Garcia-Perez and Mitra, (2007), many research works have been proved that measuring and managing of explicit knowledge is more appropriate than tacit knowledge resources. The knowledge management research and practice communities agree on the importance of identifying and measuring tacit knowledge-based resources, while absence of suitable instruments designed to apply to it continues to be a problem.

Most dominantly interviewing and observation are found to be the most appropriate methods to collect a tacit knowledge from domain experts (Forsythe, 1993). In this study, observation methods of knowledge acquisition has been applied to determine how experts in blood transfusion performing their job. This prevents the knowledge engineer from inadvertently interfering in the process. The tacit Knowledge about blood transfusion is obviously in the mind of health professionals, especially physicians and technical experts in the blood laboratory and blood bank areas.

In this study, both the direct and indirect knowledge elicitation methods are employed. The researcher observes practical tasks taken in blood transfusion. Once patients came to get blood transfusion in Black Lion Hospital, they are expected to come with a close relative who can voluntarily donate blood in Ethiopian Red Cross. Then, the donor comes with a confirmation letter from Ethiopian Red Cross to Black Lion Hospital, where the patient gets treatment. Then, the patients' blood type identification and transfusion takes place in Black Lion Hospital.

Interviewing consists of asking the domain expert questions about the domain of interest and how they perform their tasks. Domain experts in Black Lion Hospital, blood bank section were interviewed on how blood transfusion tasks were conducted. Interviews can be unstructured, semi-structured, or structured in the literature. In this study, the structured interviewing technique is used.

Indirect knowledge elicitation such as observation, how blood donation takes place, packaging and how blood transfusion takes place were also be conducted.

It is obvious that the success of an interview session of knowledge elicitation depends on the questions asked, it is difficult to know which questions should be asked, particularly if the interviewer is not familiar with the domain, and the ability of the expert to articulate their knowledge. The expert may not remember exactly how they perform a task, especially if it is one that they perform automatically using machineries (Forsythe, 1993).

The major limitation of knowledge elicitation is that people may fail to recognize that they own knowledge, and how they use it and thus interviews often find it difficult to give complete descriptions of what they know and how they use it. This is due to many reasons; among which much of the knowledge is found in the form of tacit which is rather learnt and understood through observation and experience (Forsythe, 1993). To overcome the limitation of interview as knowledge elicitation tool, observation has been also used as a knowledge elicitation method.

The knowledge possessed by human experts is mostly unstructured and not explicitly expressed hence, the major goal of knowledge engineering is to help experts articulate what they know and document the knowledge in a reusable form.

To extract tacit knowledge from domain experts, the researcher administers interviewing to three experts in Black Lion Hospital; two nurses in the hematology unit which is under the blood bank section and one general practitioner blood bank section.

The model is built by the knowledge engineer based on information obtained during the document review and analysis and interviewed with the domain expert. In some cases, the models can be built interactively with the expert, especially if there are software tools available for model creation. But in this study, knowledge modes are constructed by the knowledge engineer.

3.2.2. Explicit Knowledge Elicitation

Such knowledge is the one that can be made explicit and shared through written language, often embedded in documents (Garcia-Perez and Mitra, 2007). Knowledge about blood transfusion was collected by referring from manuals and procedures which are designed in particular use for blood transfusion. In a document analysis the knowledge engineer involves in gathering information from existing documentation regarding blood transfusion with a human expert interaction to confirm or add to this information.

Concentrated Red Blood Cell transfusion is recommended for individuals whose blood system is producing less volume of RBC. CRC or RBC in short is prepared in blood banks and have a life time of maximum twenty one days. Patients can receive CRC from donors as described in the below table.

Recipient blood Group	Donor Blood Group							
	<u>O-</u>	<u>O+</u>	<u>A-</u>	<u>A+</u>	<u>B-</u>	<u>B+</u>	<u>AB-</u>	<u>AB+</u>
<u>O-</u>	Yes	No	No	No	No	No	No	No
<u>O+</u>	Yes	Yes	No	No	No	No	No	No
<u>A-</u>	Yes	No	Yes	No	No	No	No	No
<u>A+</u>	Yes	Yes	Yes	Yes	No	No	No	No
<u>B-</u>	Yes	No	No	No	Yes	No	No	No
<u>B+</u>	Yes	Yes	No	No	Yes	Yes	No	No
<u>AB-</u>	Yes	No	Yes	No	Yes	No	Yes	No
<u>AB+</u>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.1: RBC Blood Cell Compatibility (Considering RH factor)

As depicted in the table 3.1 above, in addition to donating to the same blood group; type O blood donors can give to A, B and AB; blood donors with blood type A and B can give to AB. The general approach in blood transfusion is, if a patient with a positive antibody is in need of blood transfusion, before the antibody or Rh factor identification and appropriate blood can be obtained which is consistent with the patient's blood type, then blood transfusion is safe in this case. One donor can donate blood within ranges of three months.

Blood group AB

Individuals who have both A and B antigens on the surface of their RBCs, and their blood plasma do not contain any antibodies against either A or B antigen. Therefore, an individual with type AB blood can receive blood from any group with AB being preferable, but can donate blood only to another type AB individual.

Blood group A:

Individuals who have the A antigen on the surface of their Red Blood Cells (RBC), can receive blood only from individuals of groups A or O, with A being preferable, and can donate blood to individuals with type A or AB.

Blood group B:

In this case, individuals who have the B antigen on the surface of their RBCs can receive blood only from individuals of groups B or O, with B being preferable, and can donate blood to individuals with type B or AB.

Blood group O (or blood group zero)

Those individuals who do not have either A or B antigens on the surface of their RBCs, but their blood serum contains anti-A and anti-B antibodies against the A and B blood group antigens. Therefore, an individual with group O RBC can receive blood only from a group O individual, but can donate blood to individuals of any ABO blood group that is, A, B, O or AB. If a patient is in need of blood transfusion in an emergency, and if the time taken to process the recipient's blood would cause a detrimental delay, O negative blood is always reserved and issued in request.

On the other hand, plasma blood product is prepared in a blood bank laboratory. It has yellowish color with a one year lifelong. As it is indicated in the above table, in addition to donating the same blood group; plasma from type AB can be given to A, B and O; plasma from types A, B and AB can be given to O.

Receipt Plasma Group	Donor Plasma Group			
	O	A	B	AB
O	Yes	Yes	Yes	Yes
A	No	Yes	No	Yes
B	No	No	Yes	Yes
AB	No	No	No	Yes

Table 3.2: Plasma CompatibilityNegative

O Negative Blood Group:

Blood group O, Rh-negative is the most common of the negative blood types. As this type is negative for all of the major group antigens and negative for the Rh factor, it is called the universal donor. A transfusion of O negative blood causes no reaction in the recipient.

A Negative Blood Group:

Group A negative patients may receive blood from either group A or group O, Rh-negative donors. Exposure to group B blood or to Rh-positive blood will cause hemolytic antibodies to form that attack the B antigen or the Rh-positive antigen. Exposure can come in the form of a miss-matched transfusion.

B Negative Blood Group:

Group B negative patients may receive blood from either group B or group O, Rh-negative donors. Exposure to group A blood or to Rh-positive blood will cause hemolytic antibodies to form that attack the A antigen or the Rh-positive antigen. Exposure can come in the form of a miss-matched transfusion or through a pregnancy.

AB Negative Blood Group:

Those are considered to be a rare case blood type whereby AB negative patients can receive blood from group AB, group A, group B, and O-group, when donors are Rh-negative. Exposure

to the Rh factor during a transfusion of miss-matched Rh-positive blood will cause the formation of anti-D in the patient. The key point towards transfusing red blood cell components is, to grant patients increase the circulating red cell mass to safeguard the insufficient oxygen delivery (Kent,et al., 1988).

According to Aspirin (2010), there are exceptionalities in blood transfusion, out of which; if ABO group compatible platelets are not available, any group can be given to a patient > 2 years of age. On the other hand, ABO compatible products should be provided for chronically transfused patients and patients < 2 years of age.

In the case of RH factor, if the recipients RH factor is positive, then positive or negative platelet and red blood cells are transfused, but for plasma blood, no RH factor consideration is required. Whereas, if the RH factor of the patient is negative, then only negative red blood cell and negative platelets are transfused and still no consideration of RH factor for plasma blood cells (Jason, et al, 2011).

It is vital for recipients of blood transfusions that they receive blood that is the same type as their own; otherwise their body's immune system will recognize the donated blood as foreign and attack and destroy it.

The following table shows selection of ABO compatible packed red cells in a prioritizing order (Tripathi, 2011).

Recipient's ABO group for Packed RBC	Donor ABO group for Packed RBC			
	1 st choice	2 nd choice	3 rd choice	4 th choice
O	O	None	None	None
A	A	O	None	None
B	B	O	None	None
AB	AB	A	B	O

Table 3.3: Selection of ABO Compatible for packed CRC

The following table depicts selection of ABO compatible for plasma blood units are also shown in the table below (Tripathi, 2011).

Recipient's ABO group	ABO group Plasma			
	1 st choice	2 nd choice	3 rd choice	4 th choice
AB	AB	None	None	None
A	A	AB	None	None
B	B	AB	None	None
O	O	AB	A	B

Table 3.4: Selection of ABO Compatible Blood for Plasma

The following table depicts selection of ABO compatible for plasma blood units are also shown in the table below (Tripathi, 2011).

Recipient's ABO group	ABO group of Platelet			
	1 st choice	2 nd choice	3 rd choice	4 th choice
AB	AB	A	B	O
A	A	AB	B	O
B	B	AB	A	O
O	O	A	B	AB

Table 3.5: Selection of ABO Compatible Blood for Platelet

At the time of transfusion if there is adverse reaction respective personnel should stop the transfusion and immediate management and treatment of severe reactions need to be evaluated and blood samples are collected from the other hand of the patient and sent to the blood bank for further investigation (Tripathi, 2011).

In all the four basic blood groups there exist two sub-groups called RH positive and RH negative. The people with the RH positive blood group have an additional RH factor or the

Rhesus factor which is named after Rhesus monkeys which first observed and discovered. Whereas the people who do not have the RH factor are said to have RH negative blood.

While blood transfusion it is very important to check the RH compatibility of blood of the donor and that of the recipient, because transfusion of RH positive blood to a person with a negative blood group leads to agglutination or clumping of blood cells thus resulting in death of the person. But it must be noted that transfusion of RH negative blood to a person with positive blood group does not harm the recipient (Aspirin, 2009).

Challenges faced during knowledge Acquisition

There are many challenges faced during knowledge acquisition. Some specific challenges are, finding out appropriate domain experts was the first challenge. This is due to the reason that there are limited numbers of blood banks in Ethiopia. In this study domain experts from the National Blood Bank and Black Lion Hospital Blood Bank were tried to consult. However, the domain experts from National Blood Bank were not participated and that was a big challenge to miss their knowledge for this system. Those experts consulted for their tacit knowledge in this study are from Black Lion hospital. For this system to be rich in facts about blood transfusion, it requires more experts to participate during knowledge acquisition.

3.3. Knowledge Structuring

The knowledge elicited from its source (as a form of tacit or explicit) is structured and modeled in an appropriate manner using appropriate tool. Knowledge structured and modeled using the appropriate structuring method and models is a one step forward for knowledge codification.

3.4. Knowledge Base Models

There are numbers of knowledge modeling techniques, such as rules in the form of First Order Logic (FOL), scripts and frame based neural networks (Priti, and Rajendra, 2010). Once knowledge is acquired, it must be documented hence knowledge base developer and/or knowledge engineer can better understand and modeled it easily. Before knowledge modeling is done, it is very critical to ask the valid questions for experts and understand the appropriate flow,

breakdown and consolidate the embedded knowledge in a structure so that implementing this knowledge results in appropriate solution for a specific problem in certain knowledge area.

It is the responsibility of knowledge engineer to select appropriate knowledge presentation scheme that is more natural, efficient, transparent, and developer friendly. In this case the acquired knowledge during knowledge acquisition is represented so that it is ready for use which involves preparation of a knowledge map and before proceeding to encoding of the knowledge in the knowledge base. In this study, production rule is used for knowledge representation due to the reason that the researcher finds it easy in converting production rules into code in a rule based knowledge base development.

3.4. Knowledge Modeling for Blood Transfusion

Knowledge modeling is a cross disciplinary approach to capture and model knowledge into a reusable format for the purpose of preserving, improving, sharing, aggregating and processing knowledge to simulate intelligence (Aronson and Turban, 2007). Knowledge is modeled after it is captured from its sources, Knowledge modeling for blood transfusion has been done after the core concepts are extracted from domain experts and secondary source of data (document) analysis. Mainly blood transfusion is done in taking consideration on each of the attributes such as whole blood transfusion, red blood cell transfusion, platelets and plasma taking with respect to absence or presence of RH factors. In this study, the concept ladder modeling technique is used to show how blood transfusion is held on.

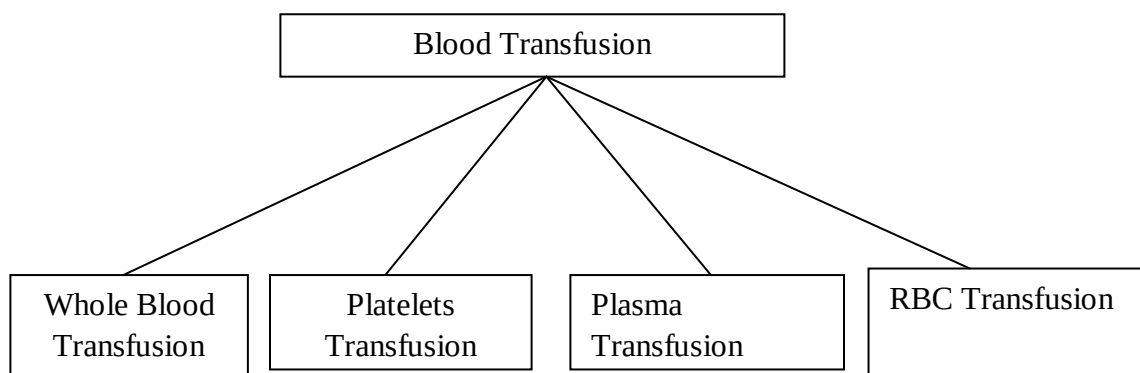


Figure 3.1: Concept Hierarchy Ladder for Blood Transfusion Categories

3.4.1. Blood group Donor (O Negative)

In the literature of blood transfusion, individuals with the blood type O negative (O-) are confirmed as universal donors due to the reason that any blood recipient can take this during transfusion and no reactions will happen in the blood system of the recipients. This blood group is free from any antigens in its surface; hence it is compatible to any blood group.

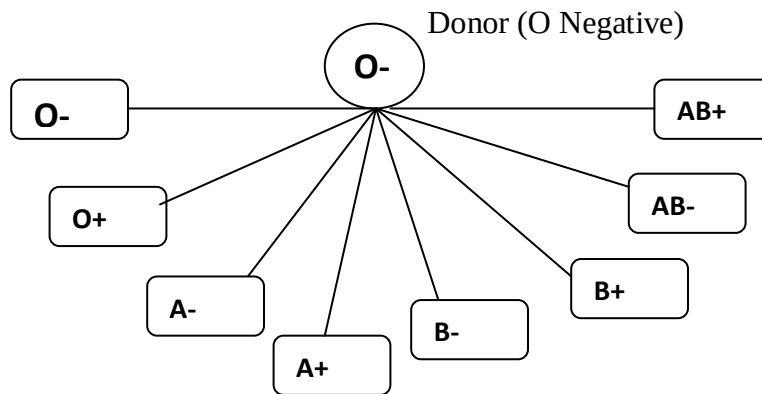


Figure 3.2: Model For RBC Group O Negative Donates To the Leafed Blood Groups (Recipients ABO)

3.4.2. Blood Group Donor (O Positive)

This blood group, O positive (O+), has antigens in its surface, and is legible to perform blood transfusion to individuals who have any of the positive blood types. But it will be illegible to transfuse O positive to the negative blood groups. The reason behind this is that, the presence of the antigens in donor's blood type can destroy by creating reaction in the recipient's blood system during the post-transfusion time.

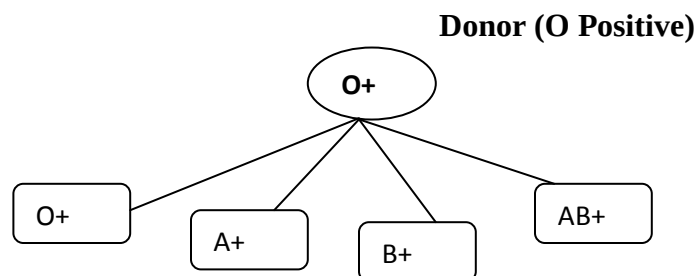


Figure 3.3: Model for RBC Blood Group O Positive Donation to the Leafed Blood Groups (Recipients ABO)

3.4.3. Blood Group Donor (A negative)

Donors with blood type A negative can give their blood during transfusion to recipients with blood group A- or A+, and AB- and AB+. The rationale behind this is that, blood type A negative has not antigens to resist recipients blood system.

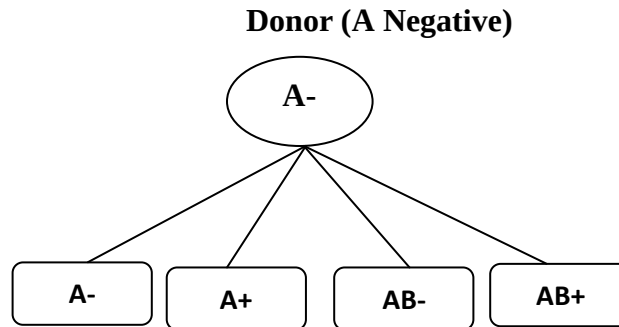


Figure 3.4: RBC Blood Group A Negative Donates to the Leafed Blood Groups (Recipients ABO)

3.4.4. Blood group Donor (A Positive)

Blood donors with blood group A positive (A+) can give only to recipients with blood group A positive itself (A+) and AB positive (AB+). This A positive blood type have antigens in its surface; hence it should not donate any blood to blood type with RH negative.

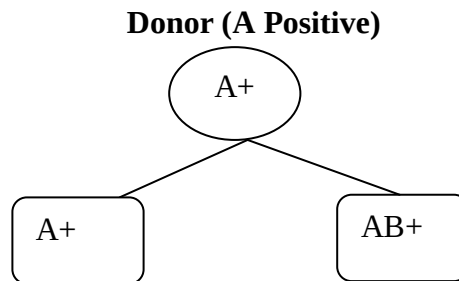


Figure 3.5: Model for RBC Blood group A positive donation to the leafed blood groups (Recipients ABO)

3.4.5. Blood group Donor (B Negative)

In the case of blood donor with blood group B negative (B-); it can give during transfusion to recipients with blood group B-, B+, AB- and AB+. There is no antigen in this blood type; hence no reaction will be created after transfusion.

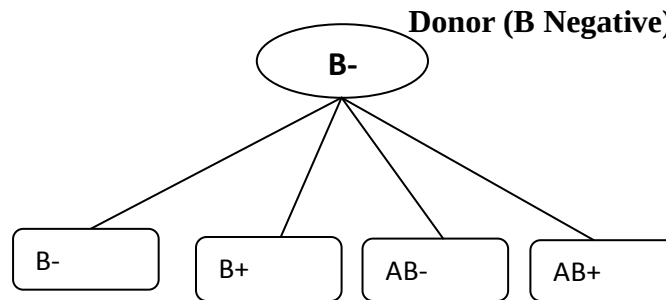


Figure 3.6: Model for RBC Blood Group B- Donation to the Leafed Blood Groups (Recipients ABO)

3.4.6. Blood Group Donor (B Positive)

Blood type B positive (B+) can only be donated to recipients with exactly the same blood type, B+, and AB+. This is due to the reason that this blood type contains antigens in its surface which can damage by causing reactions after transfusion if it is donated to other blood types due to the incompatibility.

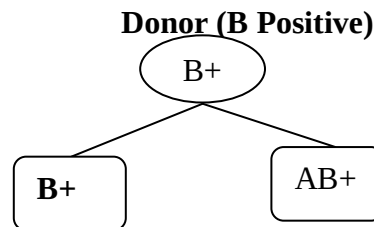


Figure 3.74: RBC Blood Group B+ Donation to the Leafed Blood Groups (Recipients ABO)

3.4.7. Blood group Donor (AB Negative)

A donor with blood type AB negative (AB) is compatible for recipients with the same blood type AB- or else AB+. This blood group is free of RH factor and antigen, hence no reaction occurs during post-transfusion period.

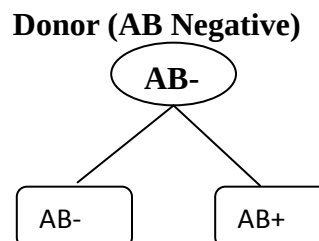


Figure 3.8: Model for RBC Blood Group AB- Donation to the Leafed Blood Groups (Recipients ABO)

3.4.8. Blood Group Donor (AB Positive)

An individual with blood group AB positive can only be donating to a recipient with exactly the same blood type. This type of blood donation is rarely occurred due to the reason that there are few people with such a blood type according to the literature of blood groupings and transfusion.

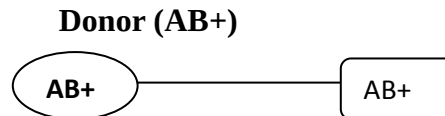


Figure 3.9: Model for RBC Blood Group AB+ Donation to Recipients Blood Groups (AB+)

3.4.9. Plasma Compatibility Structuring

Recipients can receive plasma of the same blood group, otherwise the donor-recipient compatibility for blood plasma is the converse of that of RBCs: plasma extracted from type AB blood can be transfused to individuals of any blood group; individuals of blood group O can receive plasma from any blood group; and type O plasma can be used only by type O recipients.

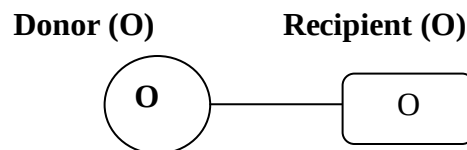


Figure 3.10: Model for Plasma Blood Group O Donation to Recipients' Blood Groups (O)

As shown below in figure 3.11 below, a blood donor, whose blood type, can donate to a recipient with blood type O or A during plasma blood transfusion.

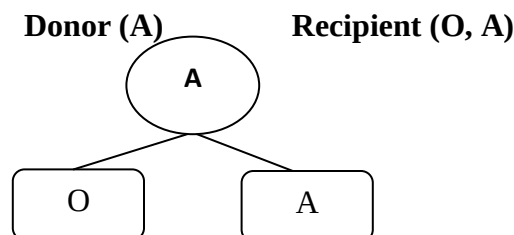


Figure 3.11: Model for Plasma Blood Group A Donation To the Leafed Recipients Blood Groups (O & A)

As depicted in figure 3.12 below, a donor with blood type B donates to a recipient with blood type B or B, when plasma blood transfusion is required.

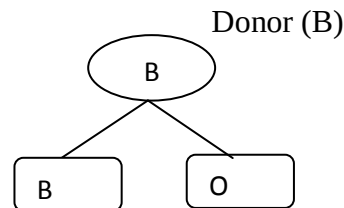


Figure 3.12: Plasma Blood Group A Donation to the Leafed Recipients Blood Groups (B & O)

Moreover, as it is indicated in figure 3.13 below, a donor with blood type AB, donates to recipients with all blood types. This is because a donor with blood type is AB universal donor in the case of plasma transfusion.

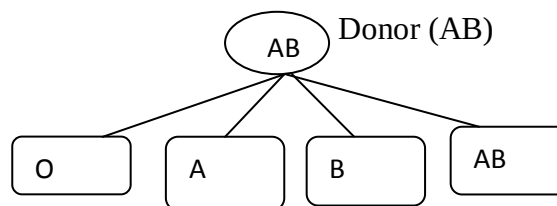


Figure 3.13: Model for Plasma Blood Group A Donation to the Leafed Recipients Blood Groups (O, A, B, AB)

3.4.10. Platelet Compatibility Structuring

Patients who are requesting platelet blood transfusion are able to take as per their compatibility test. Patients with blood type O, with no RH factor consideration, can receive the same blood type, O group, A, B and AB respectively according to their availability in blood banks. On the other hand, if patient blood type is A, then the possible plasma blood required for transfusion are, A, AB, B and O respectively. Moreover, patients with blood type B, requires blood groups B, AB, A, and O blood types. Lastly, for patients with blood type AB, the possible blood types requires for transfusion are, AB, A, B and O respectively.

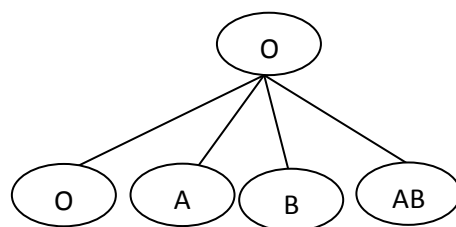


Figure 3.14: Model for Platelet Blood Group O Donation to the Leafed Recipients Blood Groups (O, A, B, and AB)

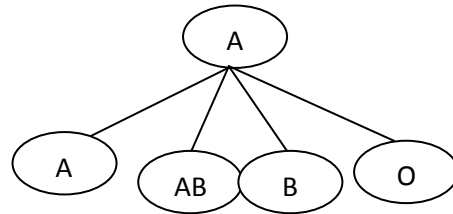


Figure 3.15: Model for Platelet Blood Group A Donation to the leafed Recipients Blood Groups (A, AB, A and O)

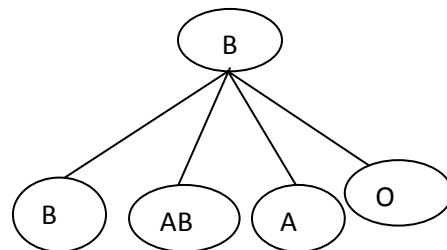


Figure 3.16: Model for Platelet Group B Donation to the leafed Recipients Blood Group (B, AB, A and O)

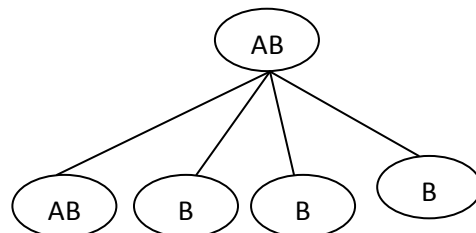


Figure 3.17: Model for Platelet Group AB Donation to the leafed Recipients Blood Group (AB, A, B and O)

3.4.11. Donor and Recipient Blood Compatibility Model for Whole Blood Transfusion

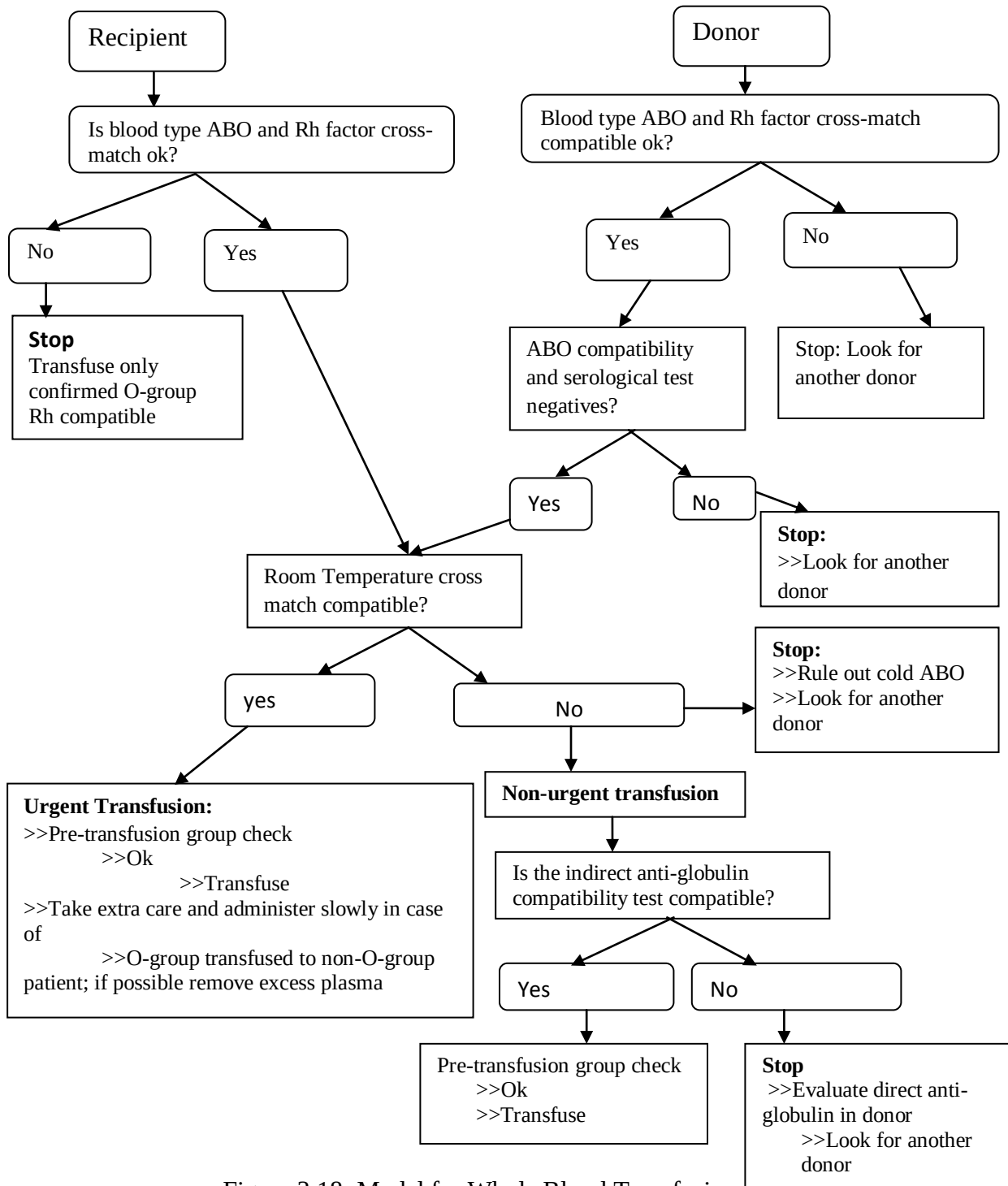


Figure 3.18: Model for Whole Blood Transfusion

Challenges faced during knowledge modeling

It was a challenging task to create a model for each classification of the blood types with respect to the compatibility of a certain blood type of donor with that of the receiver. The challenge increases when different criteria are considered in the case of whole blood transfusion. The criteria which makes the model creation challenging when whole blood transfusion is considered are; RH factor and ABO compatibility consideration, room temperature test compatibility, urgency of blood transfusion and indirect anti-globulin test. Beyond that, taking the different blood products such as; platelet, plasma and red blood cell product into consideration during modeling was a challenging task.

The challenges have been tackled by using the decision tree as a modeling technique. Decision tree is applicable to handle multiple decision points taking different criteria into consideration.

CHAPTER FOUR

4.1. Knowledge Representation and Prototype Development

The knowledge has been extracted from its sources i.e. tacit knowledge from experts and by observation and explicit knowledge through document analysis. Once knowledge is elicited and modeled in the previous chapter, knowledge representation is done using production rule. Production rules (IF-THEN-ACTION) are selected to represent the knowledge for blood transfusion. Architecture design is done in this chapter as well, which incorporates the knowledge base (facts and rules), explanation facility, inference mechanism, the knowledge base editor and the user interface are discussing in this chapter. Furthermore, the system development is done in this chapter and testing and system evaluation are also performed in the next chapter (chapter five).

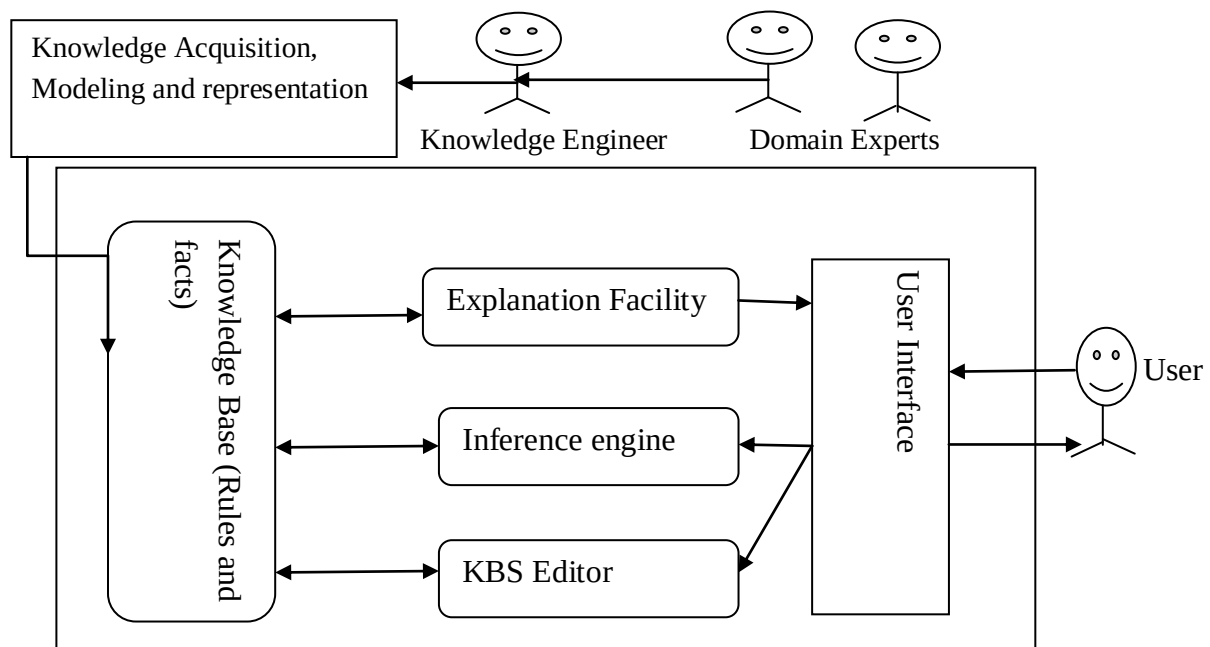


Figure 4.1: Architecture of the System

4.2. Knowledge Representation for Blood Transfusion

Knowledge based systems are developing in various form of tools and programming languages such as knowledge based shells, AI languages like LISP and prolog, or conventional languages such as Java and C++.

Rule-based reasoning is the process of drawing conclusions by relating together generalized rules, starting from scratch (Leake, 1996). The use of production rules for solving problems requires rule-based reasoning.

Knowledge representation is a key factor for acceptance, implementation and use of knowledge base system. The knowledge acquired from experts during the knowledge acquisition time is represented using production rule (IF-THEN). The following eight rules are representation of the knowledge of blood transfusion for red blood cell packages (RBC).

Rule 1:

If recipients blood type is O Negative and Blood transfusion is required, Then

The only blood choice for transfusion is O Negative.

The rational for representing rule 1 above is, if a patient whose blood type is O negative and is in need of RBC transfusion then, the only blood type required for this patient is only identical blood, which is O negative which can only be taken from a person with the same blood type. Sometimes, individuals whose blood type is O are recommended to save their own blood in blood banks hence, they can use it when required.

Rule 2:

If recipients blood type is O Positive and Blood transfusion is required, Then

Then first choice blood type is O+

Second choice blood type is O-.

On the other hand, as it is depicted in rule 2 above, a patient whose blood type is O positive can receive blood during blood transfusion from an individual with the same blood type as a first option or from donors whose blood type is O negative.

Rule 3:

If recipients blood type is A- and Blood transfusion is required, Then

Then first choice blood type is A-,

Second choice blood type is O-.

Rule 3, above indicates that a patient with blood type A negative have two options of blood types to take during blood transfusion. The first option is A negative identical type and the second one O negative.

Rule 4:

If recipients blood type is A+ and Blood transfusion is required, Then

Then first choice blood type for transfusion is A+,

Second choice blood type for transfusion is A-,

Third choice blood type for transfusion is O-,

Fourth choice blood type for transfusion is O+.

A patient, whose blood type is A positive on the other hand, has four options of blood types to take for transfusion of RBC. The first one to be the identical one followed by A negative, O negative and O positive as second, third and fourth options respectively as indicated in rule 4 above.

Rule 5:

If recipients blood type is B- and Blood transfusion is required, Then

Then first choice blood type for transfusion is B-,

Second choice blood type for transfusion is O- .

As indicated in rule 5 above, if a patient with blood type B negative is in need of RBC blood transfusion then, there are two options, the first one to be the same blood type, B negative, and the second option O negative.

Rule 6:

If recipients blood type is B+ and Blood transfusion is required, Then

First choice blood type for transfusion is B+,

Second choice blood type for transfusion is B-,

Third choice blood type for transfusion is O-,

Fourth choice blood type for transfusion is O+.

Rule 6 above shows that, a patient with blood type B +, has four options to transfuse in the case of RBC transfusion. Out of which, the first option is B positive blood, which is identical with that of the patient. The second option to be B negative, followed by O negative and O positive as third and fourth options respectively.

Rule 7:

If recipients blood type is AB- and Blood transfusion is required, Then

Then first choice blood type for transfusion is AB-,

Second choice blood type for transfusion is A-,

Third choice blood type for transfusion is B-,

Fourth choice blood type for transfusion is O-.

Moreover, a patient with blood type AB negative has four options to take from during RBC blood transfusion in a prioritized order. The first option is the identical blood type one, AB negative. Next options are A negative and B negative as second and third options respectively. Furthermore, O negative blood type is a fourth option for this patient.

Rule 8:

If recipients blood type is AB+ and Blood transfusion is required, Then

Then first choice blood type for transfusion is AB+,

Second choice blood type for transfusion is A-,

Third choice blood type for transfusion is B-,

Fourth choice blood type for transfusion is AB-,

Fifth choice blood type for transfusion is A+,

Fifth choice blood type for transfusion is B+,

Sixth choice blood type for transfusion is O-,

Seventh choice blood type for transfusion is O+.

Lastly, if patient with blood type AB positive is in need of RBC blood transfusion, then all blood types are compatible with certain degree of prioritization to choose from according to the availability of the blood types on hand. The patient first requires taking AB positive, because priority is given to exactly same type. As a second and third option, the patient requires A and B negatives respectively. Moreover, the patient requires taking AB negative and A positive respectively as a fourth and fifth options respectively. As a six and seventh option B positive and O Negative and finally O positive are required respectively for such a patient.

On the other hand the knowledge of blood transfusion for plasma blood cells is represented as follows. This representation does not consider any of the antigens and anti-bodies factor for the reason that RH factor is not considered during this type of blood transfusion. This type of blood transfusion is the converse of RBC transfusion except for the same blood type.

Rule 1:

If recipients' plasma blood type is AB and Plasma transfusion is required, Then

The only plasma type for transfusion is AB.

As shown in rule one above, a patient with blood type AB and in need of blood transfusion has to take only AB plasma type. In case the other plasma types are transfused, the patient can be prone to post-transfusion reactions.

Rule 2:

If recipient's plasma type is A and Plasma transfusion is required, Then

First choice plasma type for transfusion is A,

Second choice plasma type for transfusion is AB.

Furthermore, a patient with blood type A and in need of plasma blood product transfusion is required to take A type plasma blood product as a first option due to the identically blood types are always require as a first option. Second option for such a patient is AB plasma blood product as shown in rule two above.

Rule 3:

If recipient's plasma type is B and Plasma transfusion is required, Then

First choice plasma type for transfusion is B,

Second choice plasma type for transfusion is AB.

As depict in rule three above, the case of plasma blood transfusion requirement for patient with blood type B, the first option is B plasma product and the next requirement is AB plasma blood product.

Rule 4:

If recipient's plasma type is O and Plasma transfusion is required, THEN

The first choice plasma type for transfusion is O,

Second choice plasma type for transfusion is AB,

Third choice plasma type for transfusion is A,

Fourth choice plasma type for transfusion is B.

On the one hand, for a patient with blood type O and requires undertaking plasma blood product transfusion, there are four options. As a first option O plasma blood product is administer for transfusion. AB and A plasma products are second and third options and lastly B is administered as shown in rule four above. O plasma is considered as universal recipient in converse to the O RBC, which is universal donor in this case.

Furthermore, knowledge representation for the platelets blood type is shown as follows. As that of the plasma blood transfusion, platelets blood type does not considered RH factor during tranfusion. The difference between platelets and plasma blood products transfusion is that, plasma blood product do not considered RH factor (negative or positive) or presence or absence of antigens and antibodies.

Rule 1:

If recipient's platelet type is O and Platelet transfusion is required, THEN

Then the first choice platelet type for transfusion is O,

Second choice platelet type for transfusion is A,

Third choice platelet type for transfusion is B,

Fourth choice platelet type for transfusion is AB.

As shown in rule above above, for a platelet blood product transfusion, when a patient with O blood type is required to undertake blood transfusion then, there are four possible options. The first option is the identical one, O platelet blood product, a second, third and fourth options are; A, B and AB platelet blood products respectively.

Rule 2:

If recipient's platelet type is A and Platelet transfusion is required, THEN

The first choice platelet type for transfusion is A,

Second choice platelet type for transfusion is AB,

Third choice platelet type for transfusion is B,

Fourth choice platelet type for transfusion is O.

Furthermore, for a patient whose blood type is A and is required to take platelet blood transfusion then, this patient needs A platelet as first option, followed by AB, B and O platelet blood products for transfusion as second third and fourth options respectively as indicated in rule 2 above.

Rule 3:

If recipient's platelet type is B and Platelet transfusion is required, THEN

The first choice platelet type for transfusion is B,

Second choice platelet type for transfusion is AB,

Third choice platelet type for transfusion is A,

Fourth choice platelet type for transfusion is O.

For a patient with blood type B, who requires platelet blood transfusion, the first blood product to be selected is B platelet, this because priority is given to similar blood products. In addition, the patient needs to transfuse AB, A and O platelet products as second third and fourth options respectively as shown in rule 3 above.

Rule 4:

If recipient's platelet type is AB and Platelet transfusion is required, THEN

The first choice platelet type for transfusion is AB,

Second choice platelet type for transfusion is A,

Third choice platelet type for transfusion is B,

Fourth choice platelet type for transfusion is O.

As indicated in rule 4 above, for a patient with blood type AB, in case of platelet blood product transfusion, AB plasma product is considered as first option followed by A as a second option. Moreover, for this patient, plasma blood products B and O are recommended as third and fourth options.

Knowledge Representation for whole blood Transfusion

Donor and recipient blood compatibility for whole blood transfusion takes specific variables into consideration such as; ABO compatibility test, room temperature compatibility test, urgent and non-urgent transfusion conditions. These rules are represented as follows.

Whole blood transfusion is required for patients, whose blood volume is reducing alarmingly, or for patients who lose their blood due to emergency cases and birth delivery. As shown in rule one below, in order to transfuse whole blood for patients, the donors and recipients blood type (ABO) compatibility is tested, and if it is compatible it goes for room temperature test to check if the recipients and donors blood temperature is compatible(negative). On the other hand, if ABO blood type is incompatible (positive) then, blood transfusion is not administered, hence another donor is required.

Rule 1:

If ABO and RH cross-match is compatible and ABO compatibility and serological test is negative, THEN

Go for room temperature test.

If ABO and RH cross-match is incompatible and ABO compatibility and serological test is

positive, THEN

Stop transfusion and look for another donor.

Moreover, as it is indicated in rule 2 below, in case the room temperature test is compatible and transfusion requirement is urgent, then the ABO compatibility is rechecked and blood transfusion is administered by taking extra care on the flow of blood, slow transfusion is recommended by removing excess plasma in order to take care of concentrated red blood cells. However, if transfusion is non-urgent, further step for indirect anti-globulin compatibility test takes place before administering transfusion to check the iron and hemoglobin concentration on the RBC part of the whole blood to be transfused.

Rule 2:

If room temperature cross-match is compatible and Transfusion is required urgently, THEN

Check pre-transfusion group if it is the same ABO,

Take extra care and administer transfusion slowly in case of O-group-to-non-O-group patient,

If possible remove excess plasma to have CRC.

If room temperature is compatible and Transfusion is non-urgent, THEN

Perform indirect anti-globulin compatibility test before administering transfusion.

In case room temperature is incompatible and transfusion requirement is urgent, slow blood transfusion of one of the O group is allowed. However, if transfusion is non-urgent, no blood transfusion is allowed in this case, hence another donor with compatible room temperature is required as shown in rule 3 below.

Rule 3:

If room temperature cross-match is non-compatible and Transfusion is required urgent, THEN

Administer transfusion slowly in case of O-group-to-non-O-group patient,

If possible remove excess plasma.

If room temperature cross-match is non-compatible and Transfusion is required non-urgent, THEN

Then stop to transfuse cold ABO and look for another donor.

As shown in rule 4 below, if the anti-globulin test of the blood of the donor and recipient is compatible, in this case administering blood transfusion is safe. However, if the anti-globulin test is incompatible, further rechecking of the blood type (ABO) compatibility is required.

Rule 4:

If indirect anti-globulin test is compatible and Pre-transfusion group is ok, THEN
Perform transfusion.

If indirect anti-globulin test is incompatible and Pre-transfusion group is not ok, THEN
Recheck the ABO group before administering transfusion.

4.3. Knowledge Base for Blood Transfusion

The already represented rules during knowledge representation are codified in the in SWI-prolog to develop the KBS for blood transfusion. Sample rules for blood transfusion are shown below. The IF-THEN rules in the prolog development environment work starting from the conclusion to back to the premises due to the built in backward reasoning mechanism.

Sample knowledge base to transfuse whole blood cells are shown as follows

Rule 1:

Administer (transfusion):-

Go for (room Temp test),

ABO compatibility and serological test (compatible),

ABO & RH cross-match (Compatible).

Stop transfusion and look for (another donor):-

ABO compatibility test and serological test (Positive),

ABO and RH cross-match (compatible).

The system looks first into the conclusions “Administer (transfusion)”, and “Stop transfusion and look for (another donor)” in the case of rule 1 above, then looks back into the premises. After each fact is checked against the rules, it displays for the user.

Rule 2:

Administer (transfusion slowly o-group to non-group patients):-

Remove (excess plasma),

Transfusion case (urgent),

Room temperature cross-match (compatible).

Perform (indirect anti-globulin compatibility test before administering transfusion)

Transfusion case (non-urgent),

Room temperature cross-match (compatible).

In the case of rule 2 above, the system first checks one of the goals “administer (transfusion slowly o-group to non-group patients)” or “perform (indirect anti-globulin compatibility test before administering transfusion)”. Next each fact and rule which satisfies either of the conclusions is checked; finally the system displays the decision to the user.

4.4. Inference Engine

In a rule based KBS system, there are two widely known approaches to control the inference mechanism of the system, which are backward and forward inference mechanisms. In this study the forward reasoning mechanism is used to infer for the blood transfusion system.

In this study, the system works by continuously accepting input from users by giving query options to fill, then after comparing the input with the inference rules used, it draws conclusion by looking all the facts and rules which can be satisfied a certain condition.

First prolog accepts user profile such as patient name, gender (m. or f.), patients age group (child, adult or old), and asks for what type of blood transfusion is required (whole, platelet,

plasma, RBC). Then, prolog holds the values patient (Gender, Age_group, Blood_type, Type) and the system continuously asks questions if ABO is compatible or not, if room temperature is compatible or not and if transfusion requirement is urgent or not, then after the values in these predicates; (ABO_RH_Compatible, RomTemp_Compatible, Trans_Urgent, Res); are found, finally conclusion is drawn.

Challenges Faced during knowledge presentation

The main challenges faced during knowledge representation are, bring the model into more structured representation of the facts and procedures which are considered during blood transfusion by domain experts. Converting these facts and procedures into computer understandable code using the SWI-prolog editor was not an easy task. It was time consuming to undertake the facts and procedures into the syntax of prolog so as appropriate results are displayed for the user. Should the system connected with other development tools such as C#, VB.NET or ASP.NET for user interface, it will become more practical than currently it is.

4.5.Explanation Facilities

One of the more interesting features of knowledge based systems is their ability to explain themselves. Given that the system knows which rules were used during the inference process, it is possible for the system to provide those rules to the user as a means for explaining the results. In this study, explanation facilities such as; What, Why and Why-Not are incorporated.

The “WHAT” and “WHY” Explanation Facilities

(Before Decision is made)

This explanation facility creates a better communication between the system and the user, in case the user is not clear with some result from the system. For example, the system gives the command to the user to insert the “Gender” of the patient. In this case the user may not concern with insertion of the “Gender” hence, the user asks to the system by saying “what”. Then the system responds by saying” This is to mean: Is the patient “Male” or “Female”. Consequently the user asks for another question “WHY”, being interested to know why is the need of inserting the “Gender” of a patient. Finally, the system tries to understand the user by saying “Because the Treatment for Male and Female who can give Birth Differs”. Then user inserts either of the

genders (m/f) and the system proceeds for another command “Please Insert The age group of the patient from (Child, Adult, and Old-Aged)”. A sample interaction of the system and the user is shown below.

When the system is requested to undertake blood transfusion, it starts asking the user to enter patient name. When the user inserts name, then the system again ask the user to enter gender of a patient. The user again asks the system what gender is and why it is required to insert gender. The system argues the necessary reasonings supporting by explanation facilitates. Once the user insets either of the genders, age group, blood product required (whole, platelet, plasma, rbc) and blood type of the patien, recheaches sub-decision.

The System Recommends as Follows Before Administering Transfusion For:Name

1. First choice Blood Type for Transfusion is AB –
2. Second option is A –
3. Third Option is B –
4. Fourth Option is O - (First option in the case of Emergency)

There is still a dialog between the user and the system until final decision is made. The system asks the user if the sub-decision made is enough. According to the response of the user (Yes/No), the system made a final decision. If the user is not satisfied by the subdecision made, the user asks further question “WHYNOT”, hence the system gives explanation for the raised question.

- ✓ Enter patients Name: **Name**
- ✓ “Please Insert The Gender of the Patient”? (What): **What**
- ✓ “This is to mean: Is the Patient male or female” (Why): **Why**
- ✓ “Because the Treatment for Male and Female who can give Birth Differs”
- ✓ “So is the Patient Male or Female” (m/f): **f.**
- ✓ “Please Insert the Age Group of the Patient?” (Child, adult or old)? **Adult**
- ✓ “Please Insert Blood Product Required for Transfusion (whole, platelet, plasma, rbc)?” **rbc.**
- ✓ “Please Insert RBC Blood Type of the Patient (a_Negative, a_Positive, b_Negative, b_Positive, ab_Negative, ab_Positive, o_Negative, o_Positive)?” : **ab_Negative.**

The System Recommends as Follows Before Administering Transfusion For:Name

1. First choice Blood Type for Transfusion is AB –
 2. Second option is A –
 3. Third Option is B –
 4. Fourth Option is O - (First option in the case of Emergency)
- ✓ Do you Understand? (yes/no): **no.**
 - ✓ Why not rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)? **a_Positive.**

This is because A+ RBC causes Post-transfusion reaction for adult female Patient

Figure 4.2: Example of Inference (Forward Inferencing)

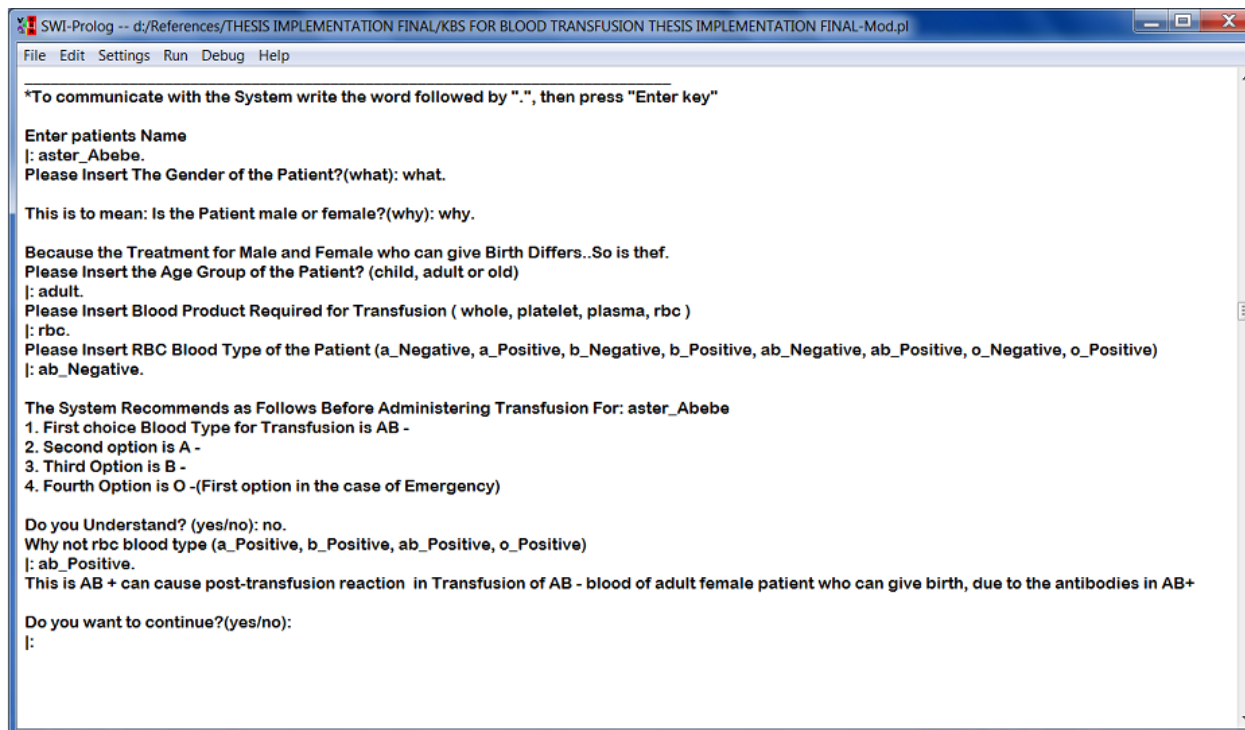


Figure 4.3: Sample Inferencing Dialog Between the system and the User

The “WHY-NOT” Explanation Facilities

(After Decision is made)

The “why-Not” explanation facility is used in this study after decision is made by the system. The interaction between the user and the system goes as follows. As shown in the following sample interaction, once the system reaches final decision on the sequences of the priority of blood types required for transfusion for a certain patient, the user may not clear with the final decision. In this case the user raises question “WHYNOT”. Then the system gives more elaborative answer to the question raised by the user.

As shown below the system reaches a final decision after looking the last query of the user and asks the user “Do you understand?” then, the user can respond by saying “Yes” if the final decision made by the system is clear. If the user has confusion on the response of the system, further question “WHYNOT rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)” is asked to the system. Lastly, the system gives an explanation the reason why (a_Positive, b_Positive, ab_Positive, o_Positive) are not selected as shown in the following sample prototype.

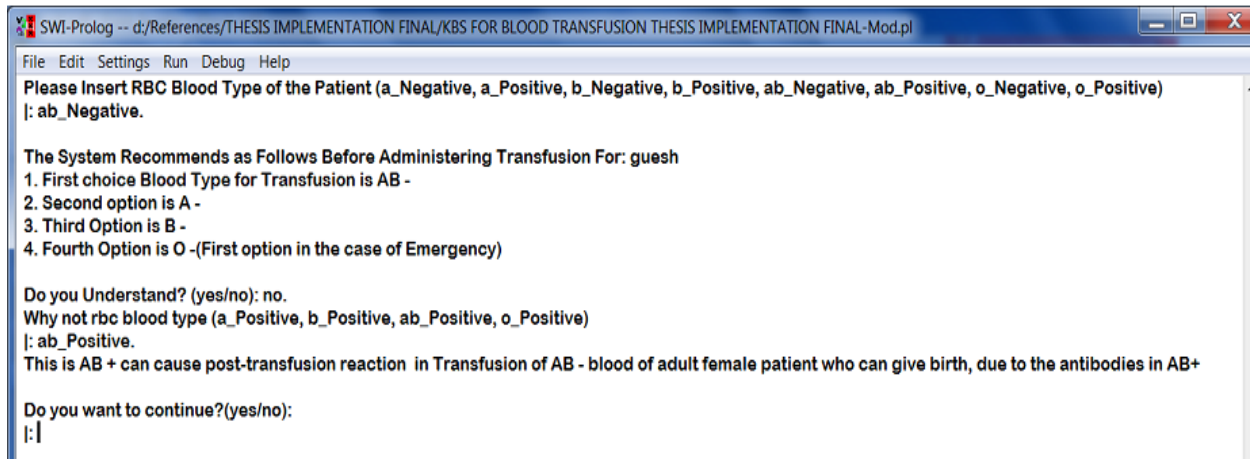


Figure 4.4: Sample Dialog of “WHY-NOT” Explanation Facilities

CHAPTER FIVE

5.1. System Testing and Evaluation

The acceptance of a knowledge based system depends to a great extent on the quality of the system such as the user interface and the explanation facilities. The user can enter queries, and respond to questions. The system responds to commands, and asks questions during the inference process.

In this study, WSI-prolog is used as a user interface to enable users communicates with the system interactively. WSI-prolog editor is commonly used tool for the development of specific knowledge based systems in the area of AI. A SWI-prolog editor is a knowledge base development tool which works in representing facts and rules. Users communicate with this interface using multiple forms of queries as per the design of the system.

As it has discussed in the methodology, SWI-Prolog editor is used for the system's development. In this study, users login to the system by writing the word "start" followed by full stop "." in the SWI-prolog environment. The welcome window for the system is shown as follows which prompt end users to interact through the system.

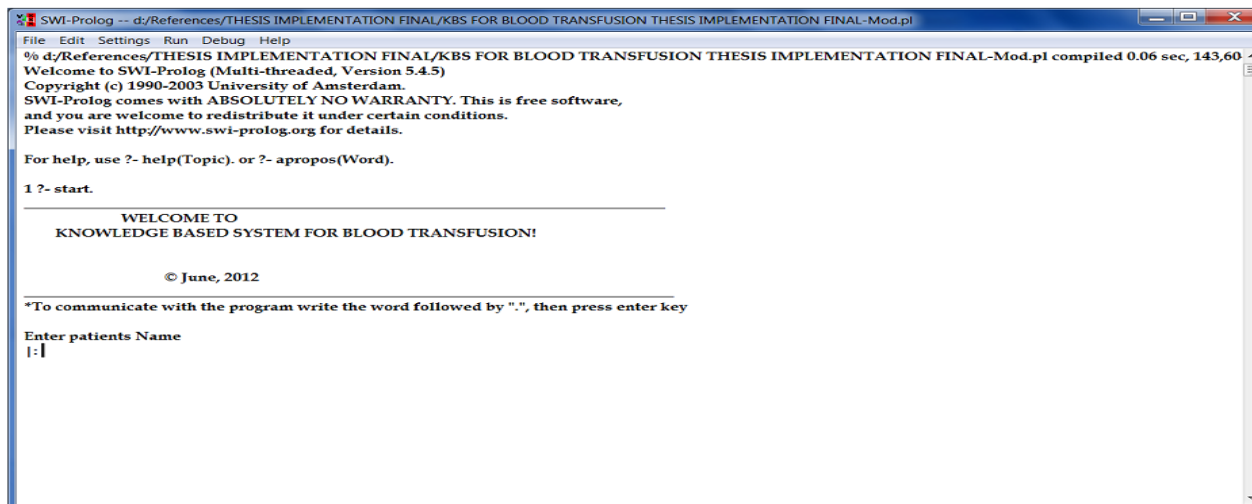


Figure 5.1: A Snapshot to the Welcome window of the Blood transfusion Knowledge Based System

5.1.1. Discussion on How the System Works

The system mainly has a main function patient and predicates. The predicates are Gender to identify whether the patient is male or female. The system treats differently for females of adult age who are at the age of pregnancy, and for child aged individuals when RBC transfusion is required. But the system treats equally for both genders (m/f) in the case of whole, plasma and platelet blood transfusion. Other predicates considered in this system are; Age; which holds three values, child, adult or old-aged patient. Moreover, Blood_product is another predicate which holds the value of the blood to be transfused; whole blood transfusion, RBC, plasma or platelet blood products. Another predicate is Type, which holds value for RBC, plasma and platelets. It does not considered value for whole blood. In the case of RBC, the Type predicate holds the values; (a_Negative, a_Positive, b_Negative, b_Positive, ab_Negative, ab_Positive, o_Negative, o_Positive). For plasma and platelet the values are the same (ab, a, b, o), they only differs during treatment. Furthermore, ABO_RH_Compatible is another predicate which holds the value of whole blood transfusion compatibility test of donors and recipients. The predicate RomTemp_Compatible is used to handle room temperature test of the blood of both donors and recipients. Furthermore, the predicate Trans_Urgent is applied to check whether transfusion issue is urgent or non-urgent. Lastly, the predicate Res is displaying the conclusion drawn by the system. The conclusion is reached by the system after the SWI-prolog editor built-in inference engine searches for patterns that match individual facts.

```
Patient(Gender, Age_group, Blood_product, Type, ABO_RH_Compatible, RomTemp_Compatible,  
Trans_Urgent, Res):-
```

Once users login into the system, they can interact with the system as per their need. Users need to fill patients name, gender and age group (child, adult or old-aged) before proceeding to the main subject of the system such as; selecting blood products (whole, platelet, plasma, red blood cell) for transfusion. Moreover, users interact with the system by selecting blood type with respect to Rh factor (a_Negative, a_Positive, b_Negative, b_Positive, ab_Negative, ab_Positive, o_Negative, o_Positive) for red blood cells and selecting one of plasma blood type from (ab, a, b, o) is performed and conclusion is drawn by the system.

Furthermore, for a platelet blood types transfusion, users are expected to select from platelet blood types (ab, a, b, o) and perform next steps accordingly. For a whole blood type transfusion, users should go through at least three conditions; whole blood (ABO) compatible (y/n), room temperature compatible (y/n) and checking whether transfusion is argent or not (y/n).

In this study, one test case is done for each of the three blood products (platelet, plasma and RBC) blood types and three test cases for whole blood product. The following snapshot is a result of one test case on RBC for a female patient, whose blood type is B negative.

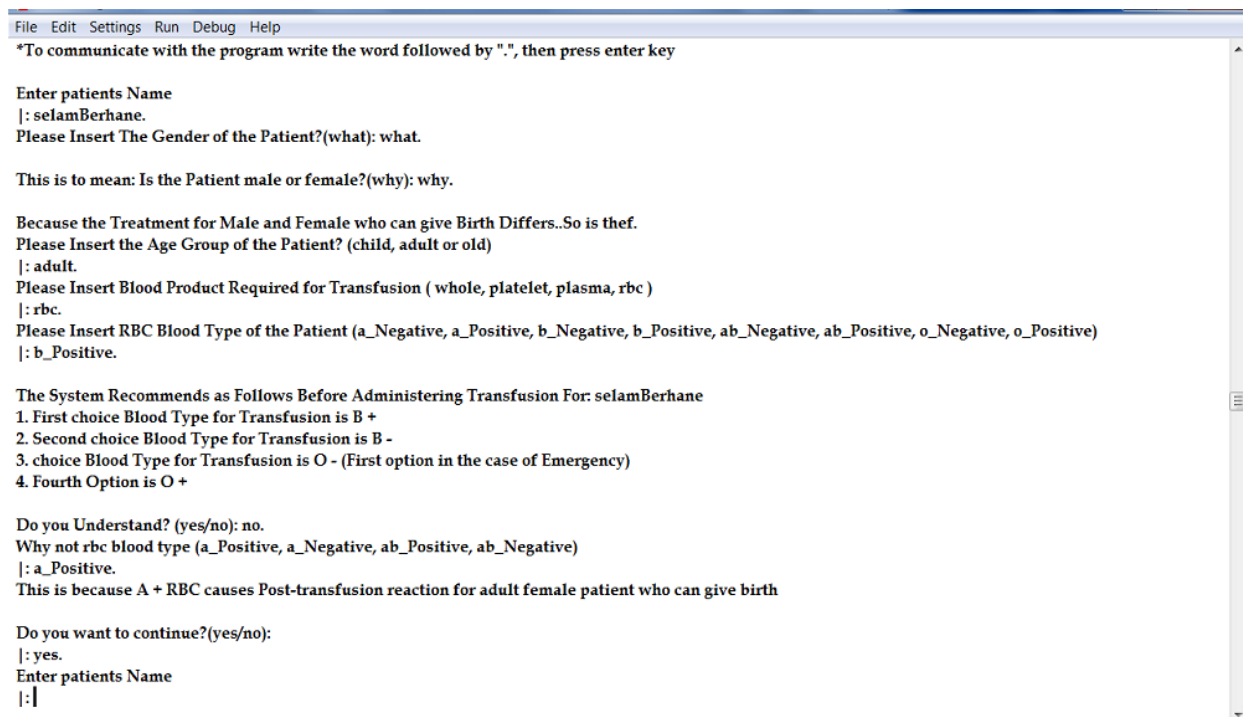


Figure 5.2: Sample snapshot for Red Blood Cell Transfusion Decision

A test result for an old-aged male patient, whose plasma blood is AB and is in need of plasma transfusion, is shown in the following in the following snapshot window.

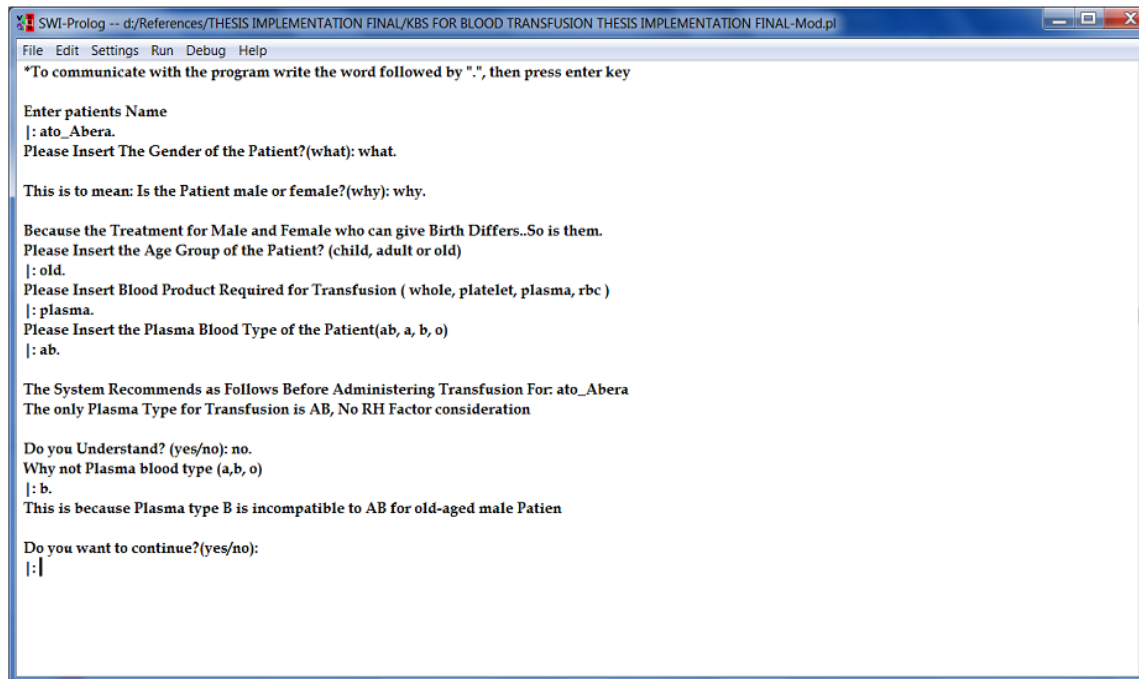


Figure 5.3: Sample snapshot for Plasma Cell Transfusion Decision

For a child male patient who is in need of platelet transfusion, whose platelet blood type is O, the test result is shown in the following snapshot window. The system responds the possible platelet types suggested during transfusion.

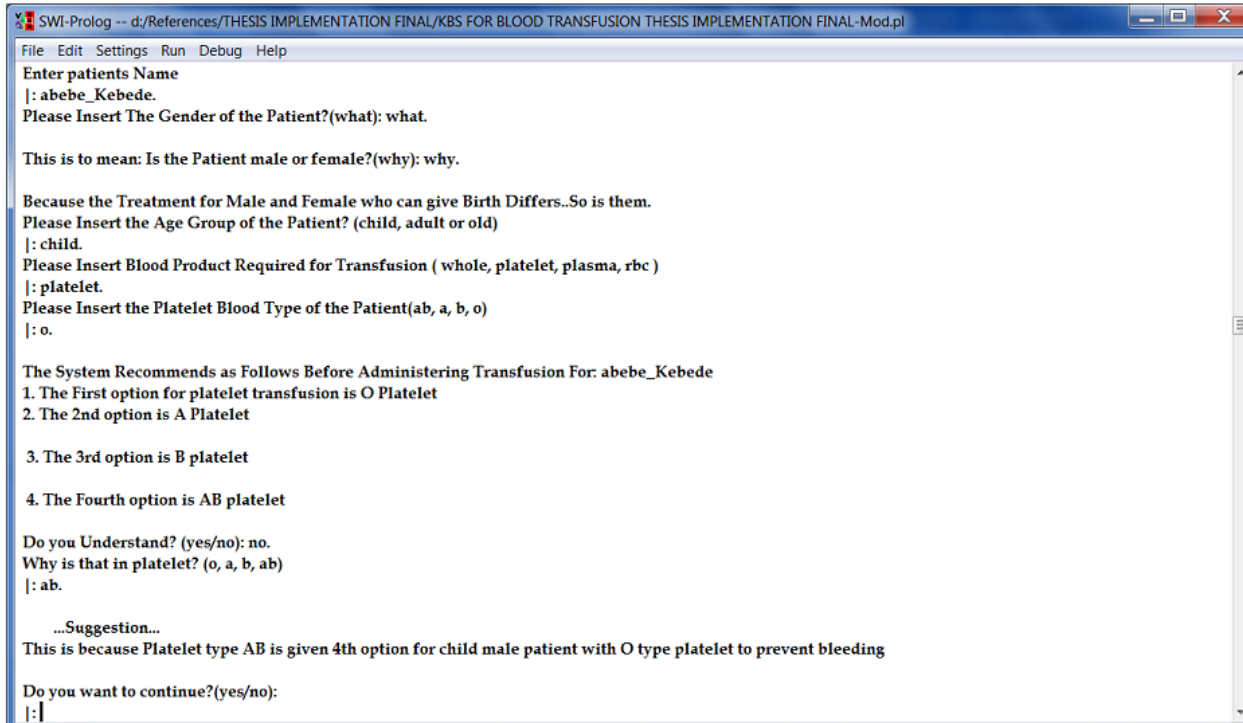


Figure 5.4: Sample snapshot for Platelet Blood Cell Transfusion Decision

On the other hand a sample snapshot window for whole blood transfusion, for a female patient, with child age group is shown in the following sample figure. Users in this case are expected to interact in a dialog manner so that final decision is reached based on the result of dialog.

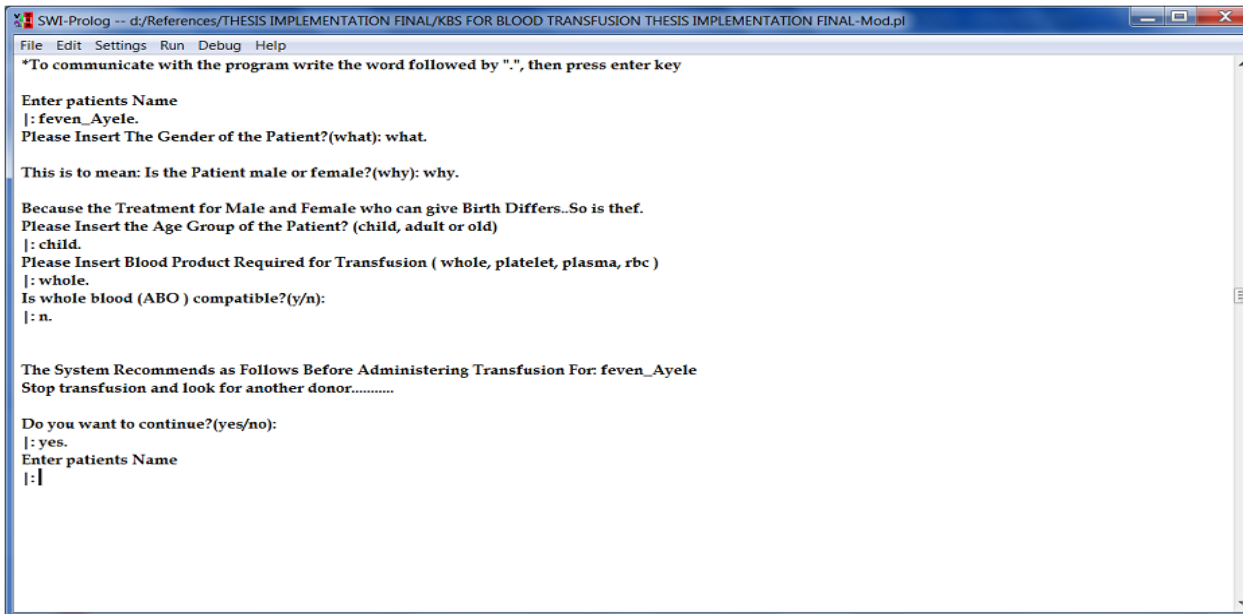


Figure 5.5: Sample Snapshot for Whole Blood Transfusion (Non-compatible ABO Group)

Furthermore, test case for a male old-aged patient who is in need of whole blood transfusion in the case of argent transfusion requirement is shown in the following snapshot window.

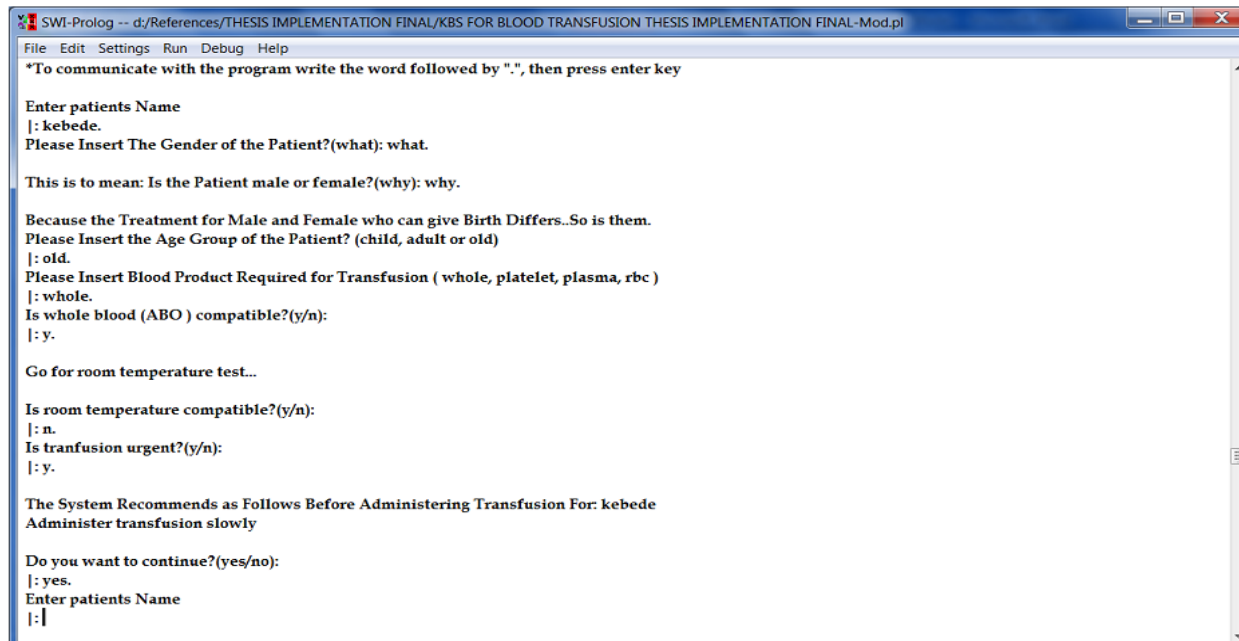


Figure 5.6: Sample Snapshot for Whole Blood Transfusion (Non-compatible Room Temperature)

For an adult female patient, who is in need of whole blood transfusion in a non-

urgent case is treated by domain experts as shown in the snapshot window below. In this case, ABO compatibility test, room temperature test and anti-globulin test are performed sequentially.

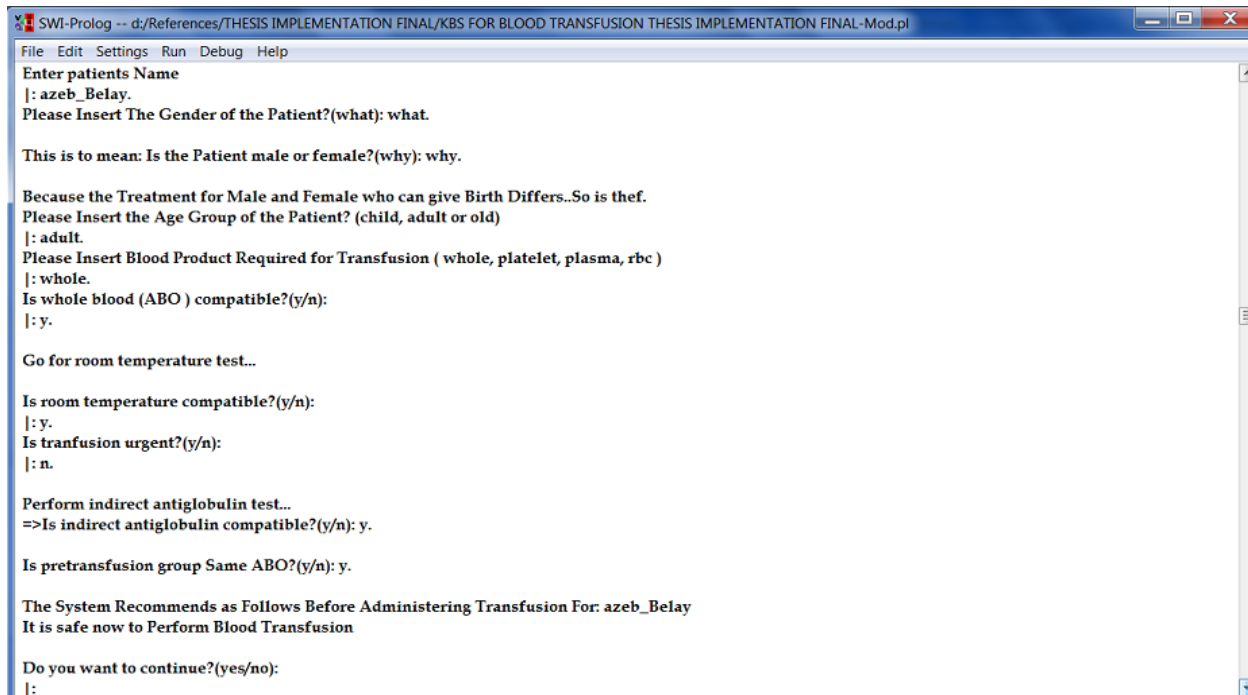


Figure 5.7: Sample Snapshot for Whole Blood Transfusion (Non-urgent Whole Blood Transfusion)

5.2. Testing and Evaluation

To test a knowledge based system, it is necessary to choose the set of test cases which will be used for the test. In particular it is very important to have a good coverage of each part of the knowledge base. Therefore, the sets of test cases must be built very carefully.

According to Meseguer, (1993), KBS evaluation is a process of checking the system against the predetermined formal requirements. In a knowledge based systems, complete translation and representing of all the requirements is very difficult due to the subjective nature of knowledge and new research outputs.

In this study, the system's content consistency is tested to verify the completeness of every question raised by domain experts. The testing is done on each result of the explanation facility. Accordingly the system is verified and late comments by domain experts are included in the

model of this KBS, hence some rules are modified and such a modification makes the knowledge base more comprehensive.

Once the refinement and verification processes are completing, user acceptance test is administered. In this case, potential users in the area of blood transfusion are included. Testing is done with the objective to determine the systems expectation and intended goals. Moreover, validation of the system has been done by taking criteria such as user interaction and explanation facility as per domain experts' expectation in the real world.

Before testing and evaluation of the system, the researcher gave a brief introduction to the subjects on the objective of the system, on how the system works and how end users can interact with the system. Moreover, brief introduction on the scope and significance of the study is given to the focused users.

In this study, six intended users from Black Lion hospital Blood Bank section are participated to administer blood transfusion testing cases and evaluation. Before end users involve in using the developed prototype for blood transfusion, a short training was given to them basically on how to use the system.

The users selected for evaluating this system are from Black Lion Hospital, Blood bank Section. The users selected for the purpose of testing and evaluations of the system are familiar with the day-to-day activities of blood transfusion. The hematologist was selected purposely to get his experts. However the five nurses were selected randomly from fourteen nurses. They were ready to act when they are evaluating the system.

Potential users were told to administer three test cases of blood transfusion for patients with different gender and age groups; child, adult and old-aged by selecting patient's blood products for transfusion such as whole blood cell, RBC, plasma and platelets. A total of seventy two (72) tests are performed by domain experts, twelve (12) tests for one domain expert. Three (3) trials were done for each of the four (4) test cases, for the categories of patients, child, adult and old-aged, on four (4) of the blood products; whole blood, RBC, plasma and platelet.

The testing and evaluation was done separately by one domain expert, who is specialist in blood transfusion, and by nurses who are operational workers in blood transfusion. Tests done by the

specialist on the system registers 83.33%, ten (10) of the twelve test cases are found to be complete knowledge, and 16.67%, two (2) of the twelve test cases became incomplete knowledge and vague.

No	Test cases (By the Specialist)	%
1.	Complete knowledge for transfusion	83.33%
2.	Incomplete and ambiguous knowledge for transfusion	16.67%

Table 5.1: Summary of Test results by Specialist (Domain Expert)

Furthermore, sixty (60) test, are performed by nurses and the system registers 81.67%. Fourty nine (49) of the sixty (60) cases register complete knowledge and 18.33%, which is eleven (11) of the test cases found to be iccomplete knowledge for blood transfusion.

There is a gap of 1.67% difference on the test result done by specialist domain expert and by the nurses. The specialist's evaluation is better than the nurses' evaluation. The reason behind is that there is unbalanced knowledge required for blood transfusion between specialist and the nurses.

No	Test cases (By Nurses)	%
1.	Complete knowledge for transfusion	81.67%
2.	Incomplete and ambiguous knowledge for transfusion	18.33%

Table 5.2: Summary of Test Results by Nurses (Domain Experts)

There is gap of knowledge which can be narrowed through training and continous communication during blood transfusion. This system is used also to limit that gap, because it incorporates knowledge of the specialists in addition to the knowledge of the nurses.

No	Average Test case results (By the Specialist and Nurses)	%
1.	Complete knowledge for transfusion	82.5%
2.	Incomplete and ambiguous knowledge for transfusion	17.5%

Table 5.3: Summary of Average Test Results by Nurses and Specialist

After the interaction period of the users with the system is completed, they were requested to answer the questions prepared for the evaluation of the system by putting a tick mark against their preference in the given rating scale. The value of the rating scale considered in this research is marked in the questionnaire.

No	Criteria	Average Score	%
1.	Compatibility of the system with respect to Blood product Transfusion as a criteria for system evaluation	5	100
2.	Applicability of the system for blood transfusion	4	80%
3.	System's completeness to administer blood transfusion	5	100
4.	Usefulness of the system as a training tool for blood transfusion	5	100%
	Average		95%

Table 5.4: Summary of Users Evaluation for the System by One Domain expert Specialist

As it is shown in table 5.5 below, the evaluation of the system by domain experts is found to be moderately valid system for blood transfusion. The system performs relatively as what the domain experts administers blood transfusion for patients in need of it. In general the system registers a promising result which paves a way to a new research direction in the area to make it full-flagged knowledge based system for blood transfusion.

No	Criteria	Average Score	%
1	Compatibility of the system with respect to Blood product Transfusion as a criteria for system evaluation	3.675	73.5%
2	Applicability of the system for blood transfusion	4.2	84%
3	System's completeness to administer blood transfusion	3.85	77%
4	Usefulness of the system as a training tool for blood transfusion	4.75	95%
	Average		82.375

Table 5.5: Users Evaluation of the system by Five Domain experts (Nurses)

Moreover, potential domain experts found the system achieving very promising result as a tool for training due to its explanation facility, education, consultation and support. The system registers encouraging result hence it can be used as a supporting tool to strengthen blood transfusion system for domain experts. The system is found to be applicable for administering blood transfusion, because it incorporates the complex procedures in a more responsive and evidently manner.

More recommendations are given for the system by domain experts during the evaluation. Some of the recommendations given are; the system needs to be more users friendly by incorporating other tools for user interface instead of communicating through the SWI-prolog editor interface. Furthermore, the system can be more applicable if it incorporates a blood screening module so that domain experts can refer it in parallel to the blood transfusion procedure. The system should also be commented to have post-blood transfusion treatments for patients to minimize post transfusion reactions.

Comments by target users of the system suggest that, there a problem which can be a hot research area to incorporate blood screening with blood transfusion. Currently blood screening is done separately in the National Blood Bank of Ethiopia found under the Ethiopia Red Cross Society, which deals with type identification and tagging. On the other hand, blood transfusion is conducted in hospitals by ordering blood products from the National Blood Bank of Ethiopia. Hence incorporating these separate units is highly recommended by domain experts.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Knowledge based system, which is a branch of Artificial, has a number of application areas. Knowledge based system is widely used in the area of medical fields especially for diagnosis and treatment. In this study, knowledge based system is developed for blood transfusion to support domain experts who involves in blood transfusion.

This system is developed to support domain experts in transfusing blood to patients in need of it based on their blood type and based on the results given by physicians. Hence, in the absence of physicians, nurses can use it to administer blood transfusion.

This Knowledge Base system was developed using the concept laddering modeling method for RBC, platelets and plasma blood transfusion and decision tree for whole blood transfusion. Production rule is applied to represent knowledge before it has been codified using the SWI-prolog editor environment.

Moreover, this system is found to be applicable for training, education in some courses of hematology. The system registers a promising result after it has been evaluated by domain experts, 82.5% accurate result. The domain experts who involve in the evaluation of this system from Black Lion Hospital, Blood Bank section confirms that, the system is applicable for blood transfusion, gave valuable comments which helps as an input for further research direction, by incorporating screening of blood and blood transfusion into a single and full system.

This study is the first attempt in Ethiopia; hence domain experts who participate in evaluation of the system are keen to adopt this system to give support.

The system minimizes, if not solve, the exiting gap in expertise among professionals at different levels in blood transfusion. This system also gives a breakthrough solution to the problem; what blood for whom.

6.2. Recommendations

Currently Ethiopia is in a critical shortage of health professionals due to reasons such as brain drain nationwide and there is a great gap of expertise among those health professionals.

Mainly the output of this study helps for delivery of training for new comer professionals to the blood transfusion profession, for educational purpose, consultation, and other supportive activities to strengthen blood transfusion service.

- This study is limited to blood transfusion by accepting laboratory and diagnosis output from medical experts by using the already represented knowledge. To make the system more useful, the blood screening and transfusion practices should be incorporated, hence it will save costs such as time, man power and increases effectiveness and efficiency by increasing quality in blood transfusion.
- To develop this knowledge based systems, SWI-prolog editor environment is used, but to make this system more interactive and make life easy for potential users, other visual user interface tools should be used, such as .NET and C#.
- This system is developed after every knowledge is represented using production rule “If – Then-Action” approach. The system should be developed using other representation methods such as confidence factor rule and compare both outputs if the system gives more degrees of belief while using knowledge-based systems to get the level of certainty during blood transfusion. Confidence factor rule can indicate to what extent a certain blood type is compatible with respect to the other blood types. This can heighten up which technique are to be selected for next similar research works.
- Future researches should deal on the sequence of the compatibility of the blood transfusion using confidence factor, to make decision making on blood transfusion more evidential.

REFERENCES

- Aamodt A. and Plaza E., (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches, *AI Communications*, IOS Press. 7(1): 39-59.
- Abdul-Nasser, K., and Mahmud, A., (2009). Blood Transfusion in History, Retrieved from <http://www.ishim.net/Articles/Blood%20Transfusion%20in%20History.pdf> on January 12, 2012
- Al Ghamdi, A.(2009). Association between ABO Blood Groups and Severity of Chronic Periodontitis, 16(3): 31-41
- Aronson J., and Turban E., (2007). *Decision support system and intelligent systems*, 7th Ed., New Delhi, Prentice-Hall of India Private Limited.
- Aspirin J., (2010). BloodBook, Information About Blood, Blood Tests, Blood Disorders, Blood Diseases, Blood Test Results And Interpretation Of Blood Tests, Donation, Transfusion, Storage And Safety, Retrived from www.ascls-sd.org/sitebuildercontent/.../bloodbookwebref.pdf on February 15, 2012
- Berry, D. and Hart, E. (1993). *A Review of Expert Systems Evaluation Techniques*,
- Cabrerizo, F., P´erez, I, and Herrera-Viedma, E., (2009). Managing the Consensus in Group Decision Making in an Unbalanced Fuzzy Linguistic Context with Incomplete Information, *Journal of Knowledge-Based Systems*. 23(5): 169–181
- Cassandra, J., Leon S., Krista H., and Christopher H. (2007). Transfusion in the Patient with Sickel Cell Disease: A Critical Review of the Literature and Transfusion

Guidelines, Elsevier Inc., *Journal of Transfusion Medicine Reviews*. 21(2): 118-133.

Clarke, K., O'Moore, R., Smeets, R., (1994). A methodology for evaluation of knowledge-based systems in medicine, *Journal of PubMed*. 6(2):107-21.

Dalton, J., Ippolito, C., Poncet, I., Rossini, S., (2005). Using RFID Technologies to Reduce Blood Transfusion Errors, White Paper by Intel Corporation, Autentica, Cisco Systems, and San Raffaele Hospital

Dennis, M., (2000). *Building Expert Systems in Prolog*, Amzi inc. Ed. 2nd, Springer-Verlag, USA

Deshpande, A., (2003). Transfusion, State Blood Transfusion Council, *Journal of Health Services*, Maharashtra, Directorate, 13(4): 55-62

Dlodlolo, N., Hanter, L., Cele, C., Botha, A., and Metelerkamp, R., (2009). A Distributed Systems Approach to Knowledge-Based Systems for the Utilization of South African Wool, *AUTEX Research Journal*. 9(2): 47-53

Douglas S., Stephen S., and Alex M., (2002). Blood history, red gold, the epic story of blood, discovery and exploration. Retrieved from <http://www.pbs.org/wnet/redgold/history/timeline3.html> on February, 23, 2012

Eshach H. and Bitterman H., (2003). From Case-based reasoning to Problem-based Learning, Academic Medicine. *Journal of PubMed*. 78(5): 491-496

Evaluating Expert Systems PP. 113-118, Association for the Advancement of Artificial Intelligence (AAAI) Technical Report, Toronto, Canada.

Ferraris V., Ferraris S., Saha S., Eugene H., Haan C., David R., (2007). Preoperative Blood Transfusion and Blood Conservation in Cardiac Surgery, The Society of Thoracic

Surgeons and the Society of Cardiovascular Anesthesiologists Clinical Practice Guideline, *Journal of STS Workforce on Evidence Based Surgery*, Elsevier Inc, 83 (3): 27– 86

Ferruccio M., Nicola P., Paolo C., (2010). Tools and Methods Based on Knowledge Elicitation to Support Engineering Design, Retrived from

<http://openarchive.univpm.it/jspui/bitstream/123456789/341/1/Tesi.Cicconi.pdf>

On March 28, 2012,

Forsythe D., (1993). *Engineering Knowledge: The Construction of Knowledge in Artificial Intelligence*, SAGE Journals, Sage Publications Ltd. 23(3): 445-477

Garcia-Perez A., and Mitra A., (2007). Tacit Knowledge Elicitation and Measurement in Research Organisations: A Methodological Approach. *The Electronic Journal of Knowledge Management*, Cranfield Defense and Security, UK, Shrivenham, 5(4): 373 – 386

Hernández-Medrano A., Hernández-Gómez L., Hernández-Simón L., (2011). Knowledge-Based System Model to Support Diabetes Research and Clinical Process. *Review of Colomb Biotechnol*, Rio De Janeiro, Brasil, 13(2): 10-26.

Hope T., and Meseguer P., (1993). Validation, verification and Testing Terminology: A Proposal. *Journal of IEEE Expert*. 8(3): 48-55

Jason T., Alan T., Dean F., and David A., (2011). Transfusion of Red Cells in Hematopoietic Stem Cell Transplantation: *Journal of Study protocol for a randomized controlled trial*, 12(1): 207-219.

- Kent S., Marc J. C., and Robert B. (1988). The Transfusion Advisor: A Knowledge-based System for the Blood Bank, , *Proceedings of the Annual Symposiums on Computer Application in Medical care*, UK PubMed Central December 9, 1988, PP. 18–21
- Koshio A, Akiyama M. (2009). Blood Transfusion and Patient Safety with IT, Minimizing risk of transfusion with Point-of-Act-System, Retrieved from <http://pari.u-tokyo.ac.jp/policy/paper/O-09.pdf> on January 20, 2012.
- Lifschitz V., Morgenstern L., and Plaisted D. (2007). Knowledge Representation and Classical Logic., Chapter 1, Elsevier, Retrieved from <http://www-formal.stanford.edu/leora/Ch1-071707.pdf> On January 12, 2012
- Marco R., Maria T. La R., Serenella C., Roberto M. (2011). Effects of red blood cell transfusions on exercise tolerance and rehabilitation time after cardiac surgery, *Journal of PubMed*. 45(3): 299-303
- McClelland D. and Pirie F., (2010). Manual of Optimal Blood Use, Support for safe, clinically effective and efficient use of blood in Europe, Published by Scottish National Blood Transfusion Service. Retrieved from www.optimalblooduse.eu/assets/pdf/blood_use_manual.pdf on December 15, 2011
- Mohamed R., and Julie T., (2009). Knowledge Based Expert Systems in Bioinformatics, France. Retrieved from http://www.intechopen.com/source/pdfs/6704/InTech-Knowledge_based_expert_systems_in_bioinformatics.pdf on September 28, 2011.
- Neelam D., (2010). World health organizations (WHO) Screening donated blood for transfusion transmissible infections, recommendations, WHO Library, Cataloguing-in

Publication Data. Retrived from,

<http://www.who.int/bloodsafety/ScreeningDonatedBloodforTransfusion.pdf> on

February 02, 2012.

Phil L., (2006). National Blood Service, A Short History of Blood Transfusion, Scientific & Technical Training. Retrieved from
www.sld.cu/galerias/pdf/sitios/.../history_of_transfusion.pdf

Place J., Truchaud A., Ozawa K., Pardue H., and Schnipelsky P., (1995). Use of artificial intelligence in analytical systems for the clinical laboratory, *The Journal of Automatic Chemistry*, Hindawi Publishing Corporation, 17(1): 1-15.

Priti S., and Rajendra A., (2010). Advanced Knowledge Based Systems: Model, Applications & Research, Kulhapur, India, National Chung Hsing University, Taichung, Taiwan.
1(5): 1 – 11.

Raman V., and Prasad K., (1987). Applications of Knowledge Based Systems in Mining Engineering, *Proceedings of the Twentieth International Symposium on the Application of Computers and Mathematics in the Mineral Industries*. 1: 167- 180

Rechard D., and Bruce B., (1982). Principles of Rule-Based Expert Systems, Heuristic Programming Project'. *Technical Report No.626*, New York: Academic Press.
22(5): 63-71

Reid S. (1985). Knowledge-Based Systems Concepts, Techniques, Examples. Retrived from
[http://www.reidgsmith.com/Knowledge-Based_Systems -
_Concepts_Techniques_Examples_08-May-1985.pdf](http://www.reidgsmith.com/Knowledge-Based_Systems_-_Concepts_Techniques_Examples_08-May-1985.pdf) on October 5, 2011.

- Reid S. (1985). Representation In Knowledge-Based Systems, Retried from <http://www.reidgsmith.com/Representation in Knowledge-Based Systems AI EUROPA Sep-1985.pdf> on October 1, 2011.
- Rhem J., (2002). A Framework for Knowledge Acquisition, Providing today's Solutions with Tomorrow's Technology, *White Paper*; Retrieved on February 12, 2012 from <http://www.ajrhem.com/framework.pdf>
- Rudi S., Richard B., and Dieter F., (1998). Knowledge Engineering: Principles and Methods, *Spanish Council for Scientific Research, Artificial Intelligence Research Institute*, Elsevier, 25(2): 161-197
- Rusel S., and Norvig P., (2003). *Artificial Intelligence: A Modern Approach*, Ed. 2nd, Prentice Hall, Pearson Education Inc., New Jersey.
- Sasikumar M, (2007). *A Practical Introduction to Rule Based Expert Systems*. Ed. 3rd, Narosa Publishing House, New Delhi,
- Schipper J., (2008). A Knowledge-Based Toxicology Consultant for Diagnosing Multiple Disorders (Doctoral dissertation PhD Dissertation, University of Florida).
- Socha W, Moor-Jankowski, J. (2005). Blood groups of primates: present status, theoretical implications and practical applications, *Journal of PubMed* 13(1): 11-40.
- Soumeya A., (1999). Knowledge Acquisition Environment for the Design of a Decision Support System: Application in Blood Transfusion. *Journal of American Medical Informatics Association*. 13(4): 187-191.

- Spackman A. and Connelly P. (1987). Knowledge based systems in laboratory medicine and pathology: *A review and survey of the field*. Arch Path Lab Med, 78(3): 271–282.
- Sujatha R, (2007). National Blood Policy, National AIDS Control Organization Ministry of Health & Family Welfare, Government of India, New Delhi.
- Thomas S., Osuntogun A, Pitman J., Mulenga B., and Vempala S., (2009). Design and Deployment of a Blood Safety Monitoring Tool. Retrieved from <http://www.cc.gatech.edu/~vempala/papers/ICTD09.pdf> on October 6, 2011
- Tomas N., (2004). Constraint Relaxation Techniques & Knowledge Base Reuse, (Doctoral Dissertation, University of Aberdeen, Scotland, U.K), Retrieved from <http://4c.ucc.ie/web/upload/publications/phdThesis/Tomas%20Eric%20Nordlander%20PhD%20Thesis.pdf> on February 23, 2012.
- Tripathi P., (2011). A Review on Knowledge-based Expert System: Concept and Architecture. *IJCA Special Issue on Artificial Intelligence Techniques - Novel Approaches & Practical Applications AIT*. Retrieved from www.ijcaonline.org/ait/number4/SPE226T.pdf On March 12, 2012.
- Turban E., Aronson J, Liang T., (2007). *Decision support systems and intelligent systems*. Ed. 8th, Prentice-Hall of India Private Limited, *Oklahoma State, India*.
- Turban E., Sharda., and Delen D.(2010). *Decision Support and Business Intelligence Systems* Ed. 9th, Prentice Hall of India Private Limited, *Oklahoma State, India*.
- Watcharachai W., and Walita N., (2009). Medical Knowledge-Based System for Diagnosis from Symptoms and Signs, *International Journal of Applied Biomedical Engineering*. 2(1): 54-59.

Wen-Chen L., and Bor-Wen C., (2011). An Intelligent System for Improving Performance of Blood Donation, *Journal of Quality* 18(2): 173-185

World Health Organization, (2008). Universal Access to Safe Blood Transfusion, Department of Essential Health Technologies Blood Transfusion Safety Unit. *Report of the Global Consultation on Universal Access to Safe Blood Transfusion*, 9–11 June 2007, Ottawa, Canada.

APPENDICES

Appendix I: List of Blood Types with Their Corresponding Compatibility for Recipients and Donors used to Develop the Knowledge Based Systems

RED BLOOD CELLS: See Rh Requirement

Component Requested	Recipient's ABO (Blood) Group	Component ABO Group
Whole Blood	O, A, B, AB	ABO Identical
Red Blood Cells	O	O
	A	A or O
	B	B or O
	AB	AB, A, B, or O

PLASMA: No RH Requirement

Recipient's ABO Group	Component ABO Group
O	O, A, B, or AB
A	A or AB
B	B or AB
AB	AB

PLATELETS: No Rh Requirement

Recipient's ABO Group	Component ABO Group
O	O, A, B, or AB
A	A or AB
B	B or AB
AB	AB

Appendix II: The Knowledge Based System Code for Blood Transfusion

patient(Gender, Age_group, Blood_type, Type, ABO_RH_Compatible, RomTemp_Compatible, Trans_Urgent, Res):-

%RBC

((patient(Gender), Gender=='m', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 1);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 2);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 3);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 4);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 5);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Negative', Res is 6);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 7);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 8);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 9);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 10);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 11);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='a_Positive', Res is 12);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 13);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 14);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 15);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 16);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 17);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Negative', Res is 18);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 19);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 20);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 21);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 22);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 23);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='b_Positive', Res is 24);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 25);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 26);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 27);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 28);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 29);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Negative', Res is 30);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 31);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 32);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 33);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 34);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 35);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='ab_Positive', Res is 36);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 37);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 38);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 39);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 40);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 41);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='o_Negative', Res is 42);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 43);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 44);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 45);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 46);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 47);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='rbc', type(Type), Type=='o_Positive', Res is 48);

%plasma

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='plasma', type(Type), Type=='ab', Res is 49);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='plasma', type(Type), Type=='ab', Res is 50);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='plasma', type(Type), Type=='ab', Res is 51);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='plasma', type(Type), Type=='ab', Res is 52);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='plasma', type(Type), Type=='ab', Res is 53);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='plasma', type(Type), Type=='ab', Res is 54);

%Platelets

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='platelet', type(Type), Type=='o', Res is 73);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='platelet', type(Type), Type=='o', Res is 74);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='platelet', type(Type), Type=='o', Res is 75);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='platelet', type(Type), Type=='o', Res is 76);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='platelet', type(Type), Type=='o', Res is 77);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='platelet', type(Type), Type=='o', Res is 78);

% Whole Blood

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 97);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 970);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 971);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 972);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 973);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='n', Res is 974);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 98);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 99);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 100);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 101);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 400);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 401);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 402);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='child',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 403);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 980);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 990);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 991);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 992);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 404);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 405);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 406);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='adult',
patient(Blood_type), Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 407);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 981);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 982);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 983);

(patient(Gender), Gender=='m', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 984);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 408);

(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='y', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 409);

```
(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='y', Res is 410);
```

```
(patient(Gender), Gender=='f', patient(Age_group), Age_group=='old', patient(Blood_type),
Blood_type=='whole', aBO_RH_Compatible(ABO_RH_Compatible),
ABO_RH_Compatible=='y', romTemp_Compatible(RomTemp_Compatible),
RomTemp_Compatible=='n', trans_Urgent(Trans_Urgent), Trans_Urgent=='n', Res is 411)).
```

start:-

```
write('_____'), nl,
```

```
write('*To communicate with the System write the word followed by "." , then press "Enter
key"',nl,nl,dialog.
```

dialog:-

```
write('Enter patients Name'),nl,
```

```
read(Name), assert(patient(Name)),
```

```
write('Please Insert The Gender of the Patient?(what): '), read(Gend), nl,
```

```
((Gend=='what',write('This is to mean: Is the Patient male or female?(why): '), read(New),
```

```
(New=='why',nl, write('Because the Treatment for Male and Female who can give Birth Differs..So is the
Patient Male or Female (m/f)?:- '), read(Neww),
```

```
Gender=Neww,assert(patient(Gender));New=='yes',Gender=New,assert(patient(Gender));New=='no',Gen
der=New,assert(patient(Gender))));
```

```
(Gend=='yes', Gender = Gend, assert(patient(Gender)));(Gend=='no',Gender =
Gend,assert(patient(Gender))));
```

```
write('Please Insert the Age Group of the Patient? (child, adult or old)'),nl,
```

```
read(Age_group), assert(patient(Age_group)),
```

```
write('Please Insert Blood Product Required for Transfusion ( whole, platelet, plasma, rbc)'),nl,
```

```
read(Blood_type), assert(patient(Blood_type)),
```

```
((Blood_type=='platelet', write('Please Insert the Platelet Blood Type of the Patient(ab, a, b, o)'),nl,
```

```
read(Type), assert(type(Type)));
```

```

(Blood_type=='plasma', write('Please Insert the Plasma Blood Type of the Patient(ab, a, b, o)'),nl,
read(Type), assert(type(Type)));

(Blood_type=='rbc', write('Please Insert RBC Blood Type of the Patient (a_Negative, a_Positive,
b_Negative, b_Positive, ab_Negative, ab_Positive, o_Negative, o_Positive)'),nl,
read(Type), assert(type(Type)));

(Blood_type=='whole', write('Is whole blood (ABO ) compatible?(y/n): '),nl,
read(ABO_RH_Compatible), assert(aBO_RH_Compatible(ABO_RH_Compatible)),nl,
((ABO_RH_Compatible=='n');
(ABO_RH_Compatible=='y', write('Go for room temperature test...'),nl,nl,
write('Is room temperature compatible?(y/n): '),nl,
read(RomTemp_Compatible), assert(romTemp_Compatible(RomTemp_Compatible)),
write('Is tranfusion urgent?(y/n): '),nl,
read(Trans_Urgent), assert(trans_Urgent(Trans_Urgent))))),
patient(Gender,Age_group,Blood_type,Type,ABO_RH_Compatible,RomTemp_Compatible,Trans_Urge
nt,Res),

((Res is 1, nl, write("The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write(' 1. First choice Blood Type for Transfusion is A Negative'),nl, write(' 2. Next
option is O Negative for emergency'),nl,nl, write('Do You Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('->This is
because A + RBC causes Post-transfusion reaction for male child due to the presence of anti bodies in A
+')); (Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in Blood
Transfusion')); (Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-transfusion
reaction for male child due to the presence of anti bodies in B +')); (Rbc_blood_type='ab_Negative',
write('This is because AB _ is incompatible to A -')); (Rbc_blood_type='ab_Positive', write('This is
because AB + RBC causes Post-transfusion reaction for male child due to the presence of anti bodies in
AB +')); (Rbc_blood_type='o_Positive', write('This is because O + RBC causes Post-transfusion reaction
due to anti bodies in O +'))

),continue));

((Res is 2, nl, write("The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Negative'),nl, write('2. Next option

```

```
is O Negative for emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),  
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,  
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('->This is  
because A + RBC causes Post-transfusion reaction for male adult due to the presence of anti bodies in A  
+'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in Blood  
Transfusion'));(Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-transfusion  
reaction in the blood of male adult due to the presence of anti bodies in B  
+'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to A -  
')); (Rbc_blood_type='ab_Positive', write('This is because AB + RBC causes Post-transfusion reaction for  
male adult due to the presence of anti bodies in AB +')));(Rbc_blood_type='o_Positive', write('This is  
because O + RBC causes Post-transfusion reaction due to anti bodies in O +'))  
),continue))));
```

```
((Res is 3,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),  
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Negative'),nl, write('2. Next option  
is O Negative for emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),  
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,  
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('=>This is  
because A + RBC causes Post-transfusion reaction for old-aged male due to the presence of anti bodies in  
A +'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in  
Blood Transfusion'));(Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-  
transfusion reaction in the blood of old-aged male due to the presence of anti bodies in B  
+'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to A -  
')); (Rbc_blood_type='ab_Positive', write('This is because AB + RBC causes Post-transfusion reaction for  
old-aged male due to the presence of anti bodies in AB +')));(Rbc_blood_type='o_Positive', write('This is  
because O + RBC causes Post-transfusion reaction due to anti bodies in O +'))  
),continue))));
```

```
((Res is 4, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),  
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Negative'),nl, write('2. Next option  
is O Negative for emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),  
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,  
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('=>This is  
because A + RBC causes Post-transfusion reaction for Female child due to the presence of anti bodies in  
A +'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in  
Blood Transfusion'));(Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-  
transfusion reaction in the blood of Female child due to the presence of anti bodies in B
```

```

+')); (Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to A -
')); (Rbc_blood_type='ab_Positive', write('This is because AB + RBC causes Post-transfusion reaction for
Female child due to the presence of anti bodies in AB +')); (Rbc_blood_type='o_Positive', write('This is
because O + RBC causes Post-transfusion reaction due to anti bodies in O +'))

```

```

),continue));

```

```

((Res is 5,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Negative'),nl, write('2. Next option
is O Negative for emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);

```

```

(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('=>This is
because A + RBC causes Post-transfusion reaction for Adult Female due to the presence of anti bodies in
A +')); (Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in
Blood Transfusion')); (Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-
transfusion reaction in the blood of Adult Female due to the presence of anti bodies in B
+')); (Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to A -
')); (Rbc_blood_type='ab_Positive', write('This is because AB + RBC causes Post-transfusion reaction for
Female child due to the presence of anti bodies in AB +')); (Rbc_blood_type='o_Positive', write('This is
because O + RBC causes Post-transfusion reaction due to anti bodies in O +'))

```

```

),continue));

```

```

((Res is 6, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Negative'),nl, write('2. Next option
is O Negative for emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);

```

```

(YesNo='no', write('Why not rbc blood type (a_Positive, b_Negative, b_Positive, ab_Negative,
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('=>This is
because A + RBC causes Post-transfusion reaction for old-aged Female due to the presence of anti bodies
in A +')); (Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A - RBC in
Blood Transfusion')); (Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-
transfusion reaction in the blood of old-aged Female due to the presence of anti bodies in B
+')); (Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to A -
')); (Rbc_blood_type='ab_Positive', write('This is because AB + RBC causes Post-transfusion reaction for
Female child due to the presence of anti bodies in AB +')); (Rbc_blood_type='o_Positive', write('This is
because O + RBC causes Post-transfusion reaction due to anti bodies in O +'))

```

```

),continue));

```

```

((Res is 7,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),

```

```
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for male child'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is
incompatible for A + RBC in Blood Transfusion for male child'));(Rbc_blood_type='ab_Positive',
write('This is because AB + is incompatible for A + during transfusion male
child'));(Rbc_blood_type='ab_Negative', write('This is because AB Negative is incompatible to A+ during
RBC transfusion for male child'))))
```

```
),continue));
```

```
((Res is 8, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for male adult'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is
incompatible for A + RBC in Blood Transfusion for male adult'));(Rbc_blood_type='ab_Negative',
write('This is because AB - RBC is incompatible for A + RBC in Blood Transfusion for male
adult'));(Rbc_blood_type='ab_Positive', write('This is because AB + is incompatible for male adult during
RBC transfusion'))))
```

```
),continue));
```

```
((Res is 9, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for old-aged male'));(Rbc_blood_type='b_Negative', write('This is because B -
RBC is incompatible for A + RBC in Blood Transfusion for old-aged
male'));(Rbc_blood_type='ab_Positive', write('This is because AB + RBC is incompatible for A + RBC in
Blood Transfusion for old-aged male'));(Rbc_blood_type='ab_Negative', write('This is because AB - RBC
is incompatible for A + RBC in Blood Transfusion for old-aged male patient'))))
```

```
),continue));
```

```
((Res is 10, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue));
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for female child'));(Rbc_blood_type='b_Negative', write('This is because B - RBC
is incompatible for A + RBC in Blood Transfusion for femal child'));(Rbc_blood_type='ab_Positive',
write('This is because AB + RBC is incompatible for A + RBC in Blood Transfusion for for female
child'));(Rbc_blood_type='ab_Negative', write('This is because AB - RBC is incompatible for A + RBC
in Blood Transfusion for adult female child'))))
```

```
),continue));
```

```
((Res is 11, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for adult female patient at the age of child
bearing'));(Rbc_blood_type='b_Negative', write('This is because B - RBC is incompatible for A + RBC in
Blood Transfusion for adult femal at the age of child bearing'));(Rbc_blood_type='ab_Positive',
write('This is because AB + RBC is incompatible for A + RBC in Blood Transfusion for adult female at
the age of child bearing'));(Rbc_blood_type='ab_Negative', write('This is because AB - RBC is
incompatible for A + RBC in Blood Transfusion for adult female patient at the age of child bearing ')))
```

```
),continue));
```

```
((Res is 12, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is A Positive'),nl, write('2. Second
option is A Negative'),nl, write('3. Third Option is O Negative (First option in the case of Emergency)' ),
nl, write('4. Fourth Option is O Positive' )),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo),
((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (b_Positive,b_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='b_Positive', write('This is because B + RBC is incompatible to
A + during transfusion for old-aged female patient'));(Rbc_blood_type='b_Negative', write('This is
because B - RBC is incompatible for A + RBC in Blood Transfusion for old-age female
patient'));(Rbc_blood_type='ab_Positive', write('This is because AB + RBC is incompatible for A + RBC
```


in Blood Transfusion for old-age female patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - RBC is incompatible for A + RBC in Blood Transfusion for old-aged female patient'))))

),continue));

((Res is 13, nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative, ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for male child due to the presence of anti bodies in A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B - RBC Transfusion for child patient'));(Rbc_blood_type='b_Positive', write('This is B + is incompatible for B - RBC Transfusion for child patient'));(Rbc_blood_type='ab_Negative', write('This is AB - is incompatible for B - RBC Transfusion for child patient'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B - RBC Transfusion for child patient'));(Rbc_blood_type='o_Positive', write('This is because O + is incompatible for B - RBC Transfusion for male child patient'))))

),continue));

((Res is 14,nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative, ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for male child due to the presence of anti bodies in A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B - RBC Transfusion for child patient'));(Rbc_blood_type='b_Positive', write('This is B + is incompatible for B - RBC Transfusion for male adult patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible for adult male with blood type B-'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B - RBC Transfusion for adult male patient'));(Rbc_blood_type='o_Positive', write('This is because O + is incompatible for B - RBC Transfusion for male adult patient'))))

),continue));

((Res is 15, nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative, ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is

```

because A + RBC causes Post-transfusion reaction for male old-aged due to the presence of anti bodies in
A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B - RBC Transfusion for old-
aged male patient'));(Rbc_blood_type='b_Positive', write('This is B + is incompatible for B - RBC
Transfusion for old-aged male patient due to the anti-bodies in B +'));(Rbc_blood_type='ab_Negative',
write('This is because AB - is incompatible for old-aged male with blood type B-
')); (Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B - RBC Transfusion for old-
aged male patient'));(Rbc_blood_type='o_Positive', write('This is because O + is incompatible for B -
RBC Transfusion for old-aged male patient'))

```

```

),continue));

```

```

((Res is 16, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option
is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '),
read(YesNo), ((YesNo='yes',continue);

```

```

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative,
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is
because A + RBC causes Post-transfusion reaction for female child aged due to the presence of anti
bodies in A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B - RBC
Transfusion for female child patient'));(Rbc_blood_type='b_Positive', write('This is B + is incompatible
for B - RBC Transfusion for female child patient due to the anti-bodies in B
+'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B - blood type female
child patien'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B - RBC
Transfusion female patient due to anti-bodies in AB +'));(Rbc_blood_type='o_Positive', write('This is
because O + is incompatible for B - RBC Transfusion for child female patient'))

```

```

),continue));

```

```

((Res is 17,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option
is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '),
read(YesNo), ((YesNo='yes',continue);

```

```

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative,
ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is
because A + RBC causes Post-transfusion reaction for adult female who can give birth due to the
presence of anti bodies in A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B -
RBC Transfusion for adult female patient'));(Rbc_blood_type='b_Positive', write('This is B + is
incompatible for B - RBC Transfusion for adult female patient due to the anti-bodies in B
+'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B - blood type adult
female patien who can give birth'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible
for B - RBC Transfusion adult female patient who give birth due to anti-bodies in AB
+'));(Rbc_blood_type='o_Positive', write('This is because O + is incompatible for B - RBC Transfusion
for adult female patient who can give birth ')))

```

),continue));

((Res is 18, nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B Negative'),nl, write('2. Next option is O Negative =>First option during Emergency'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, b_Positive, ab_Negative, ab_Positive, o_Positive)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for old-aged female patient due to the presence of anti bodies in A +'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B - RBC Transfusion for old-aged female patient'));(Rbc_blood_type='b_Positive', write('This is B + is incompatible for B - RBC Transfusion for old-aged female patient due to the anti-bodies in B +'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B - blood type old-aged female patient')); (Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B - RBC Transfusion old-aged female patient due to anti-bodies in AB +'));(Rbc_blood_type='o_Positive', write('This is because O + is incompatible for B - RBC Transfusion for old-aged female patient who can give birth ')))

),continue));

((Res is 19, nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second option is B -'),nl, write('3. Third Option is O - (First option in the case of Emergency)'), nl, write('4. Fourth Option is O + '),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for adult male patient'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B + RBC Transfusion for adult male child patient'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B + RBC Transfusion child male patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type for child male patient'))))

),continue));

((Res is 20, nl, write('The System Recommends as Follows Before Administering Transfusion For: '), write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second option is B -'),nl, write('3. Third Option is O - (First option in the case of Emergency)'), nl, write('4. Fourth Option is O + '),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl, read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for adult male patient'));(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B + RBC Transfusion for adult male patient'));(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B + RBC Transfusion adult male

```
patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type
for adult male patien')))
```

```
),continue)))
```

```
((Res is 21,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second option is B
-'),nl, write('3. Third Option is O - (First option in the case of Emergency)' ), nl, write('4. Fourth Option is
O + '),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-
transfusion reaction for old-aged male patient'));(Rbc_blood_type='a_Negative', write('This is A - is
incompatible for B + RBC Transfusion for old-aged male patient'));(Rbc_blood_type='ab_Positive',
write('This is AB + is incompatible for B + RBC Transfusion old-aged male
patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type
for old-aged male patien')))
```

```
),continue)))
```

```
((Res is 22,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second option is B
-'),nl, write('3. Third Option is O - (First option in the case of Emergency)' ), nl, write('4. Fourth Option is
O + '),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-
transfusion reaction for child female patient'));(Rbc_blood_type='a_Negative', write('This is A - is
incompatible for B + RBC Transfusion for child female patient'));(Rbc_blood_type='ab_Positive',
write('This is AB + is incompatible for B + RBC Transfusion child female
patient'));(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type
for child female patien')))
```

```
),continue)))
```

```
((Res is 23,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second choice
Blood Type for Transfusion is B -'),nl, write('3. choice Blood Type for Transfusion is O - (First option in
the case of Emergency)' ), nl, write('4. Fourth Option is O + '),nl,nl, write('Do you Understand? (yes/no):
'), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-
transfusion reaction for adult female patient who can give birth'));(Rbc_blood_type='a_Negative',
```

```
write('This is A - is incompatible for B + RBC Transfusion for old-aged female patient who can give birth'));
(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B + RBC Transfusion adult female patient who can give birth'));
(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type for adult female patien who can give birth')))
```

```
),continue));
```

```
((Res is 24, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is B +'),nl, write('2. Second option is B -'),nl,
write('3. Third Option is O - (First option in the case of Emergency)' ), nl, write('4. Fourth Option is O + ' ),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, a_Negative, ab_Positive, ab_Negative)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A + RBC causes Post-transfusion reaction for old-aged female patient'));
(Rbc_blood_type='a_Negative', write('This is A - is incompatible for B + RBC Transfusion for adult female patient who can give birth'));
(Rbc_blood_type='ab_Positive', write('This is AB + is incompatible for B + RBC Transfusion old-aged female patient who can give birth'));
(Rbc_blood_type='ab_Negative', write('This is because AB - is incompatible to B + blood type for old-aged female patien')))
```

```
),continue));
```

```
((Res is 25, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is AB -'),nl, write('2. Second choice Blood Type for Transfusion is A -'),nl,
write('3. Third choice Blood Type for Transfusion is B - ' ), nl, write('4. Fourth choice Blood Type for Transfusion is O -(First option in the case of Emergency)'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A+ RBC causes Post-transfusion reaction Male child Patient'));
(Rbc_blood_type='b_Positive', write('This is because B + RBC causes Post-transfusion reaction in the blood of child male due to the presence of anti bodies in B +'));
(Rbc_blood_type='ab_Positive', write('This is AB + can cause post-transfusion reaction in Transfusion of AB - blood child Male patient due to the antibodies in AB+'));
(Rbc_blood_type='o_Positive', write('This is because O + can cause post-transfuion reaction the blood AB - of the male child patient')))
```

```
),continue));
```

```
((Res is 26, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is AB -'),nl, write('2. choice Blood Type for Transfusion is A -'),nl,
write('3. Third choice Blood Type for Transfusion is B - ' ), nl, write('4. Fourth choice Blood Type for Transfusion is O -(First option in the case of Emergency)'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A+ RBC causes Post-
transfusion reaction in adult Male Patient'));(Rbc_blood_type='b_Positive', write('This is because B +
RBC causes Post-transfusion reaction in the blood of adult male due to the presence of anti bodies in B
+'));(Rbc_blood_type='ab_Positive', write('This is AB + can cause post-transfusion reaction in
Transfusion of AB - blood of adult Male patient due to the antibodies in
AB+'));(Rbc_blood_type='o_Positive', write('This is because O + can cause post-transfuion reaction the
blood AB - of adult male patient'))))
```

```
),continue))));
```

```
((Res is 27, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is AB -'),nl, write('2. Second option is
A -'),nl, write('3. Third Option is B - '), nl, write('4. Fourth Option is O -(First option in the case of
Emergency)'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A+ RBC causes Post-
transfusion reaction for old-aged Male Patient'));(Rbc_blood_type='b_Positive', write('This is because B +
RBC causes Post-transfusion reaction in the blood of old-age male patient due to the presence of anti
bodies in B +'));(Rbc_blood_type='ab_Positive', write('This is AB + can cause post-transfusion reaction
in Transfusion of AB - blood of old-aged Male patient due to the antibodies in
AB+'));(Rbc_blood_type='o_Positive', write('This is because O + can cause post-transfuion reaction the
blood AB - of old-aged male patient'))))
```

```
),continue))));
```

```
((Res is 28, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. First choice Blood Type for Transfusion is AB -'),nl, write('2. Second option is
A -'),nl, write('3. Third Option is B - '), nl, write('4. Fourth Option is O -(First option in the case of
Emergency)'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not rbc blood type (a_Positive, b_Positive, ab_Positive, o_Positive)'), nl,
read(Rbc_blood_type), ((Rbc_blood_type='a_Positive', write('This is because A+ RBC causes Post-
transfusion reaction for child female Patient'));(Rbc_blood_type='b_Positive', write('This is because B +
RBC causes Post-transfusion reaction in the blood of child female due to the presence of anti bodies in B
+'));(Rbc_blood_type='ab_Positive', write('This is AB + can cause post-transfusion reaction in
Transfusion of AB - blood of child female patient due to the antibodies in
AB+'));(Rbc_blood_type='o_Positive', write('This is because O + can cause post-transfuion reaction the
blood AB - of child female patient'))))
```

```
),continue))));
```

```
%PLASMA
```

```
((Res is 49, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('The only Plasma Type for Transfusion is AB, No RH Factor consideration'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not Plasma blood type (a,b, o)'), nl, read(Plasma_blood_type),
((Plasma_blood_type='a', write('This is because Plasma type A is incompatible to AB for male & child
Patient'));(Plasma_blood_type='b', write('This is because Plasma type B is incompatible to AB for male &
child Patien'));(Plasma_blood_type='o', write('This is because Plasma type O is incompatible to AB for
male & child Patien'))))
```

```
),continue)))
```

```
((Res is 50, nl, write('The System Recommends as Follows Before Administering Transfusion For:
'),write(Name),nl, write('The only Plasma Type for Transfusion is AB, No RH Factor
consideration'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not Plasma blood type (a,b, o)'), nl, read(Plasma_blood_type),
((Plasma_blood_type='a', write('This is because Plasma type A is incompatible to AB for male & Adult
Patien'));(Plasma_blood_type='b', write('This is because Plasma type B is incompatible to AB for male &
Adult Patien'));(Plasma_blood_type='o', write('This is because Plasma type O is incompatible to AB for
male & Adult Patien'))))
```

```
),continue)))
```

```
((Res is 51,nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('The only Plasma Type for Transfusion is AB, No RH Factor consideration'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not Plasma blood type (a,b, o)'), nl, read(Plasma_blood_type),
((Plasma_blood_type='a', write('This is because Plasma type A is incompatible to AB for old-aged male
Patien'));(Plasma_blood_type='b', write('This is because Plasma type B is incompatible to AB for old-
aged male Patien'));(Plasma_blood_type='o', write('This is because Plasma type O is incompatible to AB
for old-aged Patien'))))
```

```
),continue)))
```

```
((Res is 52, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('The only Plasma Type for Transfusion is AB, No RH Factor consideration'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not Plasma blood type (a,b, o)'), nl, read(Plasma_blood_type),
((Plasma_blood_type='a', write('This is because Plasma type A is incompatible to AB for female & child
Patient'));(Plasma_blood_type='b', write('This is because Plasma type B is incompatible to AB for female
& child Patient'));(Plasma_blood_type='o', write('This is because Plasma type O is incompatible to AB
for female & child Patient'))))
```

```
),continue)))
```

```
((Res is 53, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('The only Plasma Type for Transfusion is AB, No RH Factor consideration'),nl,nl,
write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why not Plasma blood type (a,b, o)'), nl, read(Plasma_blood_type),
((Plasma_blood_type='a', write('This is because Plasma type A is incompatible to AB for female & Adult
Patien'));(Plasma_blood_type='b', write('This is because Plasma type B is incompatible to AB for female
& Adult Patien'));(Plasma_blood_type='o', write('This is because Plasma type O is incompatible to AB
for female Adult Patien'))))
```

```
),continue)));
```

```
%Platelats
```

```
((Res is 73, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. The First option for platelet transfusion is O Platelet'),nl, write('2. The 2nd
option is A Platelet'),nl,nl,write(' 3. The 3rd option is B platelet'),nl,nl,write(' 4. The Fourth option is AB
platelet'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why is that in platelet? (o, a, b, ab)'), nl, read(Platelet_blood_type),
((Platelet_blood_type='o',nl,write('This is because O is First required due to the identity to prevent
bleeding'));(Platelet_blood_type='a',write('This is because Platelet type A is given 2nd option for male
child patient with O type platelet to prevent bleeding'));(Platelet_blood_type='b',
write('\n\t...Suggestion...\n'),write('This is because Platelet type B is given 3rd option for male child
patient with O type platelet to prevent bleeding'));(Platelet_blood_type='ab',write('\n\t...Suggestion...\n'),
write('This is because Platelet type AB is given 4th option for child male patient with O type platelet to
prevent bleeding'))))
```

```
),continue)));
```

```
((Res is 74, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. O Platelet'),nl,nl,write(' 2. A Platelet'),nl,write(' 3. B platelet'),nl,nl,write(' 4. AB
platelet'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);
```

```
(YesNo='no', write('Why is that in platelet? (o, a, b, ab)'), nl, read(Platelet_blood_type),
((Platelet_blood_type='o',write('This is because O is First required due to the identity to prevent
bleeding'));(Platelet_blood_type='a',write('This is because Platelet type A is given 2nd option for adult
male patient with O type platelet to prevent
bleeding'));(Platelet_blood_type='b',write('\n\t...Suggestion...\n'), write('This is because Platelet type B is
given 3rd option for adult male patient with O type
platelet'));(Platelet_blood_type='ab',write('\n\t...Suggestion...\n'),write('This is because Platelet type AB is
given 4th option for adult male patient with O type platelet to prevent bleeding'))))
```


),continue))));

((Res is 75, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('1. O Platelet'),nl,nl,write(' 2. A Platelet'),nl,write(' 3. B platelet'),nl,nl,write(' 4. AB
platelet'),nl,nl, write('Do you Understand? (yes/no): '), read(YesNo), ((YesNo='yes',continue);

(YesNo='no', write('Why is that in platelet? (o, a, b, ab)'), nl, read(Platelet_blood_type),
((Platelet_blood_type='o', write('This is because O is First required due to the identity to prevent
bleeding'));(Platelet_blood_type='a',write('This is because Platelet type A is given 2nd option for old-aged
male patient with O type platelet to prevent
bleeding'));(Platelet_blood_type='b',write('\n\t...Suggestion...\n'), write('This is because Platelet type B is
given 3rd option for an old-aged male patient with O type
platelet'));(Platelet_blood_type='ab',write('\n\t...Suggestion...\n'), write('This is because Platelet type AB is
given 4th option for an old-aged male patient with O type platelet to prevent bleeding'))))

),continue))));

% Whole

(Res is 97, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Stop transfusion and look for another donor.....'),continue);

(Res is 970, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl,write('Stop transfusion and look for another donor.....'),continue);

(Res is 974, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Stop transfusion and look for another donor.....'),continue);

(Res is 98, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Check pre-transfusion group if it is the same ABO'),nl, write('Take extra care &
administer transfusion slowly in case of O -group-to-non-O -group patients'),nl, nl, write('remove excess
plasma'),continue);

(Res is 980, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('->Check pre-transfusion group if it is the same ABO'),nl, write('Take extra care &
administer transfusion slowly in case of O -group-to-non-O -group patients'),nl, nl, write('remove excess
plasma'),continue);

(Res is 981, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('->Check pre-transfusion group if it is the same ABO'),nl, write('Take extra care &
administer transfusion slowly in case of O -group-to-non-O -group patients'),nl, nl, write('remove excess
plasma'),continue);

write('Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,

```

((Antiglobulin_Compatible=='n', nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl,write('Stop transfusion and look for another donor.....'),continue);

(Antiglobulin_Compatible=='y', write('Is pretransfusion group Same ABO?(y/n): '),

    read(Pretransfusion_Group),

    ((Pretransfusion_Group=='y', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('It is safe now to Perform Blood
Transfusion'),continue);

    (Pretransfusion_Group=='n',nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl, write('Recheck ABO before administering
transfusion')))),continue);

(Res is 982, nl, write('Perform indirect antiglobulin test...'),nl,

write('Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,

((Antiglobulin_Compatible=='n',nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl, write('Stop transfusion and look for another donor.....'),continue);

(Antiglobulin_Compatible=='y', nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl,write('Is pretransfusion group Same ABO?(y/n): '),

    read(Pretransfusion_Group),

    ((Pretransfusion_Group=='y',nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl, write('It is safe now to Perform Blood
Transfusion'),continue);

    (Pretransfusion_Group=='n',nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl, write('Recheck ABO before administering
transfusion')))),continue);

(Res is 990, nl, write('Perform indirect antiglobulin test...'),nl,

write('->Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,

((Antiglobulin_Compatible=='n', nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl,write('Stop transfusion and look for another donor.....'),continue);

(Antiglobulin_Compatible=='y', nl, write('Is pretransfusion group Same ABO?(y/n): '),

    read(Pretransfusion_Group),

```

```
((Pretransfusion_Group=='y', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('It is safe now to Perform Blood
Transfusion'),continue);
```

```
(Pretransfusion_Group=='n',nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl, write('Recheck ABO before administering
transfusion')))),continue);
```

```
(Res is 405, nl, write('Perform indirect antiglobulin test...'),nl,
```

```
write('=>Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,
```

```
((Antiglobulin_Compatible=='n', nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl,write('Stop transfusion and look for another donor.....'),continue);
```

```
(Antiglobulin_Compatible=='y', write('Is pretransfusion group Same ABO?(y/n): '),
```

```
read(Pretransfusion_Group),
```

```
((Pretransfusion_Group=='y', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('It is safe now to Perform Blood
Transfusion'),continue);
```

```
(Pretransfusion_Group=='n', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('Recheck ABO before administering
transfusion')))),continue);
```

```
(Res is 401, nl, write('Perform indirect antiglobulin test...'),nl,
```

```
write('->Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,
```

```
((Antiglobulin_Compatible=='n',nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl, write('Stop transfusion and look for another donor.....'),continue);
```

```
(Antiglobulin_Compatible=='y', write('Is pretransfusion group Same ABO?(y/n): '),
```

```
read(Pretransfusion_Group),
```

```
((Pretransfusion_Group=='y', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('It is safe now to perform Blood
Transfusion'),continue);
```

```
(Pretransfusion_Group=='n',nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl, write('Recheck ABO before administering
Transfusion')))),continue);
```

```
(Res is 409, nl, write('Perform indirect antiglobulin test...'),nl,
```

```

write('Is indirect antiglobulin compatible?(y/n): '), read(Antiglobulin_Compatible), nl,

((Antiglobulin_Compatible=='n', nl, write('The System Recommends as Follows Before Administering
Transfusion For: '), write(Name),nl,write('Stop transfusion and look for another donor.....'),continue);

(Antiglobulin_Compatible=='y', write('Is pretransfusion group Same ABO?(y/n): '),

        read(Pretransfusion_Group),

        ((Pretransfusion_Group=='y', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('Perform transfusion'),continue);

        (Pretransfusion_Group=='n', nl, write('The System Recommends as Follows Before
Administering Transfusion For: '), write(Name),nl,write('Recheck ABO before administering
transfusion')))),continue);

(Res is 100, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Administer transfusion slowly'),continue);

(Res is 991, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Administer transfusion slowly'),continue);

(Res is 101, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Stop transfusion of cold ABO and look other donor'),continue);

(Res is 984, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Stop transfusion of cold ABO and look other donor'),continue);

(Res is 992, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('Stop transfusion of cold ABO and look other donor'),continue);

(Res is 411, nl, write('The System Recommends as Follows Before Administering Transfusion For: '),
write(Name),nl, write('->Stop transfusion of cold ABO and look other donor')),continue).

continue:-

nl,nl,write('Do you want to continue?(yes/no): '),nl,

read(ANSW), ((ANSW=yes, dialog);(ANSW=no, break)).

```

Appendix III: Sample Knowledge Base Derived from the Rules

Rules in the artificial blood choice for transfusion for RBC in the knowledge base

Rule 1:

Blood choice for transfusion (O negative):-

Recipients blood type (O negative),

Blood transfusion (required),

Rule 2:

First choice blood type (O+):-

Second choice blood type (O-):-

Blood transfusion (required),

Recipient's blood type (O+),

Rule 3:

First choice blood type (A-):-

Second choice blood type (O-):-

Blood transfusion (required),

Recipient's blood type (A-).

Rule 4:

First choice blood type (A+):-

Second choice blood type(A-):-

Third choice blood type (O-):-

Fourth choice blood type(O+)

Blood transfusion (required),

Recipients blood type(A+).

Rule 5:

first choice blood type(B-):-

second choice blood type(O-):-

blood transfusion (required),

recipients blood type(B-).

Rules in the artificial blood choice for transfusion for Plasma in the knowledge base:

Rule1:

The only possible plasma type (AB):-

Plasma transfusion (required),

Recipients plasma type (AB).

Rule 2:

First choice plasma type (A):-

Second choice plasma type (AB):-

Plasma transfusion (required),

Recipient's plasma type (A).

Rules in the artificial blood choice for transfusion of platelet in the knowledge base:

Rule 1:

First choice platelet (O):-

Second choice platelet (A):-

Third choice platelet (B):-

Fourth choice platelet (AB):-

Platelet transfusion (required),

Recipient platelet type (O).

Rule 2:

First choice platelet (A):-

Second choice platelet (AB):-

Third choice platelet (B):-

Fourth choice platelet (O):-

Platelet transfusion (required),

Recipient platelet type (A).

Rules in the artificial blood choice for transfusion of ABO compatibility test, room temperature compatibility test and urgent and non-urgent transfusion conditions in knowledge base for whole blood cell.

Rule 1:

Go for (room Temp test):-

ABO compatibility and serological test (Negative),

ABO & RH cross-mach (Compatible).

Stop transfusion and look for (another donor):-

ABO compatibility test and serological test (Positive),

ABO and RH cross-match (compatible).

Rule 2:

Administer (transfusion slowly o-group to non-group patients):-

Remove (excess plasma),

Transfusion case (urgent),

Room temperature cross-match (compatible).

perform(indirect anti-globulin compatibility test before administering transfusion)

Transfusion case (non-urgent),

Room temperature cross-match (compatible).

Rule 3:

Administer transfusion slowly (O-group to the non-O-group):-

Remove (excess plasma),

Transfusion case (urgent),

Room temperature cross-match (non-compatible)

Perform (indirect anti-globulin test before transfusion):-

Transfusion (non-urgent),

Room temp test (compatible),

Rule4:

Perform (transfusion):-

Pre-transfusion (ABO group check is ok),

Indirect anti-globulin test (compatible).

Recheck (ABO group compatibility before administering transfusion):-

Pre-transfusion (ABO group non-compatible),

Indirect anti-globulin test (compatible).

Appendix IV: Interview Questions for Elicitation of Knowledge from Experts on Blood Transfusion

1. What is blood transfusion all about? In brief.
2. What knowledge is required to involve in blood transfusion?
3. Is there any gap in how to perform blood transfusion among domain experts in (general practitioner/ Doctors and nurses)?
4. What are the procedures to be followed during blood transfusion? Is there any inappropriate procedure selected?
5. How is blood transfusion take place with respect to the different blood types available?
6. Is there any exceptionality in blood transfusion with respect to the different age groups? (child/adult and old aged) patients?
7. Is there any priority given to one blood type from another blood type during blood transfusion?
8. What major actions are taken when there is incompatibility after blood transfusion?
9. What do you think is the efficiency and effectiveness of clinical decision making regarding:
 - 9.1. Unnecessary transfusion
 - 9.2. Failure to give a necessary transfusion
 - 9.3. What if wrong blood product is transfused?
10. How is the decision made in blood transfusion which component and number of units to be transfused.
11. What if there is lack of transfusion knowledge or failure to follow guidelines from expert doing the transfusion?
12. What is ABO incompatibility reaction? How is this compatibility test (cross-match) done?

Appendix V: Questionnaire for Testing and Evaluation of KBS with Domain Experts

Name: _____

Organization: _____

Job Title: _____

1. The types of blood product transfusion commonly practiced are whole blood transfusion, red blood transfusion, platelet transfusion and plasma transfusion. *Please try to transfuse blood for a sing patient child, adult, and old-aged groups for each of the blood products [whole, RBC, Platelet and Plasma] and put a tick mark (✓) next to your choice in the following 12 trials

[Complete Knowledge] [Incomplete knowledge]

- | | | |
|---------------------|-------|-------|
| 1) Child(whole) | _____ | _____ |
| 2) Child(RBC) | _____ | _____ |
| 3) Child (plasma) | _____ | _____ |
| 4) Child(platelet) | _____ | _____ |
| 5) Adult(whole) | _____ | _____ |
| 6) Adult (RBC) | _____ | _____ |
| 7) Adult (plasma) | _____ | _____ |
| 8) Adult (platelet) | _____ | _____ |
| 9) Old(whole) | _____ | _____ |
| 10) Old(RBC) | _____ | _____ |
| 11) Old(plasma) | _____ | _____ |
| 12) Old(platelet) | _____ | _____ |

Appendix VI: Test Design to be performed by one domain expert

Patients' Age Group	Blood Product Required for Transfusion	Trial per Patient	Total Trials
Child	Whole	4	12
	RBC		
	Plasma		
	Platelet		
Adult	Whole	4	
	RBC		
	Plasma		
	Platelet		
Old-Aged	Whole	4	
	RBC		
	Plasma		
	Platelet		

2. Please put a tick mark (✓) next to your choice in the following rating scale table for the given

Compatibility of the system with respect to blood product transfusion.

1.	Compatibility of the system with respect to Blood product Transfusion	Very compatible (5)	Complete (4)	Fairly compatible(3)	Less compatible(2)	Incompatible(1)
a.	Whole Blood transfusion					
b.	Platelets Blood Transfusion					
c.	Plasma Blood Transfusion					
d.	Red Blood Cell Transfusion					

Question: Please put a tick mark (✓) next to your choice in the following rating scale table		Highly Acceptable (5)	Acceptably(4)	Fairly Acceptable(3)	Less Acceptable(2)	Unacceptable(1)
2.	What do you think is about the applicability of the system for blood transfusion?					

	Question: Please put a tick mark (✓) next to your choice in the following rating scale table	More than enough (5)	Enough (4)	Fairly Enough (3)	Less Enough(2)	Not Enough (1)
3.	Do you think that the questions asked by the system are enough and makes the system complete to administer blood transfusion?					

No	Question: Please put a tick mark (✓) next to your choice in the following rating scale table	Very useful (5)	Useful (4)	Fairly useful (3)	Less useful (2)	Not useful at all (1)
4.	How do you get the system will be useful as a training tool for blood transfusion					

5. What can you suggest to the system so as to make it full-flagged and complete?

Declaration

I declare that the thesis entitled “**Designing a Knowledge Based System for Blood Transfusion**” is my original work and has not been presented for a degree in any other university.

Guesh Dagnew Demewez

June 2012

This thesis has been submitted for examination with my approval as university advisor.

Ato Getachew Jemaneh

June 2012