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SCHOOL OF COMPUTING & INFORMATICS

CASE BASED REASONING FOR TREATMENT AND MANAGEMENT OF DIABETES

By

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A project report submitted in partial fulfillment of the requirements for the award of Masters of Science in Applied Computing of the University of Nairobi

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DECLARATION

This project is my original work and, to the best of my knowledge, this research work has not been submitted for any other award in any University.

Mark K. Kiragu: _____ Date: _____

P51/64907/2013

This project report has been submitted in partial fulfillment of the requirements for the Master of Science Degree in Applied Computing of the University of Nairobi with my approval as the University supervisor.

Peter W. Wagacha: _____ Date: _____

School of Computing and Informatics

DEDICATION

I thank God and I dedicate this work to my parents, family and friends for their support and encouragement.

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Prof. Peter Waiganjo Wagacha has been the ideal supervisor his guidance, patience, time and his intellect helped the actualization of this research. I am so grateful to the other School of Computing & Informatics staff especially Christopher Moturi, Dan Orwa and Samuel Ruhiu for their constant support, supervision and correction of this project. I deeply appreciate their assistance. I also acknowledge the medical experts and the community of Diabetes Management Information Centre and The Diabetes Association of Kenya for their guidance and support during the research, development and implementation of the prototype.

ABSTRACT

This study focused on the use of case based reasoning (CBR) for treatment and management of diabetes. CBR is a field of artificial intelligence where one uses past cases as resolution for similar problems. The concept is based on dynamic memory theory where human beings solve problems by recalling encountered cases.

This project applies CBR in the field of medicine for treatment and management of diabetes. Diabetes is a family of metabolic disease condition where the patient has elevated blood glucose. There is a rise on the prevalence of diabetes in Kenya with over 2 Million Kenyans suffering from the condition. Damage to nerves, heart failure, kidney failure, blindness and amputations are among the diabetes associated complications. Some of the key challenges encountered during the management of diabetes include lack of insulin, high cost of drugs, an overworked workforce and low awareness among others.

A prototype was developed using JCOLIBRI framework and trained with a total of 60 cases. 40 cases were type 1 and the remaining 20 cases type 2. A test data of 20 cases was used to measure the accuracy of the system. The key variables used in test were blood glucose, HBA1C (average blood glucose over 3 months), weight and height. The diagnosis predicted by the system were compared against the one obtained by the expert and the results were as follows: When tested with the 3 parameters (Blood Glucose, Height & Weight) the system had a mean accuracy of 28% before revision (3^{rd} Cycle of CBR) and after the first revision (3^{rd} Cycle of CBR) the system attained a mean accuracy of 70% with the 3 parameters. When tested with 1 parameter (Blood Sugar) after revision (3^{rd} Cycle of CBR) the system returned a mean accuracy of 90%.The accuracy was based on the difference of solution applied between an expert judgment and the system judgment. The level of blood glucose is the key factor to consider during diabetes diagnosis.CBR is more accurate after revision cycle and as the number of cases increased.

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Abbreviations Acronyms and Symbols

AI:	Artificial Intelligence
CBR:	Case Based Reasoning
CDC:	Centre for Disease Control
IGM:	Information Gain Metric
NCD:	Non-Communicable Disease
WHO:	World Health Organization
ADA :	American Dental Association
KNN:	k-Nearest Neighbors
HBA1C	Glycated Hemoglobin
Mg/dl	Milligrams per Deciliter
Mmols	Millimoles
<	Less-than
&	Ampersand
%	Percentage
>	Greater-than

Definitions of terms

Term	Definition
Case based reasoning:	Denoted as **CBR** is the process of solving new problems based on the solutions of similar previous solutions. Sometimes it is also referred to as a Case Base Reasoner that solves current new problems by using or adapting solutions that were used to solve previous problems.
Case:	A case in CBR is a **problem-solution** pair that is captured for future problem resolution. A problem is made up of several features that describe it. Cases are records of real events.
JCOLIBRI:	Is a framework that provides a platform that defines a clear architecture to design CBR systems.
Soft Computing:	A field of computing that models human mind.
Neural Network:	Is a statistical learning model inspired by biological neural networks.
Machine Learning:	Is a field of learning that evolved from pattern recognition and learning.
Genetic algorithm:	Is the process of revolving new populations by use of genomes.
Nearest Neighbor:	Is a method used in CBR to retrieve the best matching past cases.
Diabetes:	Is a group of metabolic disease in which the person has elevated blood glucose.
Precedent:	Is the process of finding similarity in situations in other words pattern matching.
Artificial Intelligence:	Is the field of academic field which studies how to create computers and computer software that are capable of intelligent behaviour.

CHAPTER 1

1.0 Introduction

Background of the Study

Case Based Reasoning (CBR) is a concept that combines problem-solving and integrates learning (from a collection of previous knowledge /experience i.e. cases).CBR has become one of the most successful sub-fields of artificial intelligence (AI) of recent years Juan et.al (2008).It is based on a belief that problems tend to recur.CBR is founded in the works of Roger Schank on dynamic memory and the central role that a reminding of earlier situations (cases) and scripts (situation patterns) has in problem solving and learning. CBR has its background in soft computing methodologies. CBR has been advanced from soft computing methodologies borrowed from artificial intelligence. A.I is a method of learning emanating from concept representation by use of symbols, learning implementation by use of abstraction, pattern identification use of previous knowledge, natural language processing and data training.

A number of other reasoning and knowledge acquisition methods include neurobiology which is inspired by a mechanism used by biological organisms to process information. Other examples include Control theory which is based on the use of theoretical abstraction to predict and control the next state of a process; Computational complexity theory, a method of imposing learning complexity boundaries on tasks based on the effort, efficiency, and effectiveness and learning mistakes gathered from experience, and Bayesian methods which are a way of calculating probabilities in hypothesis and a basis of predicting values in unobserved variables.

Other theories informing CBR especially in the selection phase include decision trees used for inductive inference which involves learning from the factors that contribute to a problem. It approximates the specific valued functions in which a tree represents the learned function. A tree is simply a classifier. A node represents a value and the branch proceeding from the nodes represent the values of the attributes. An instance is represented at the root node of a tree.

Whenever we are presented with a problem we try to recall a previous problem and the steps or methods we used to resolve the problem. We then employ the same set of actions to solve the new problem. CBR uses the **4 R methodology** that involves Retrieval, Reuse, and Revision and Retention principles. CBR is a branch of Artificial Intelligence where reasoning and learning is implemented by retaining cases in a knowledge base and has a mechanism of search, matching, retrieve of cases and employs a method of updating of these cases for re-use and finally indexing and retaining these cases for future problem resolution. (Adebayo et al, 2014).

CBR systems have proven to be more effective in problem resolution as opposed to other fields of A.I in the sense that whereas other fields of A.I require a very deep causal model and a rich knowledge of the field, CBR can work very well in fields where there is scanty knowledge. Rule based systems have a poor learning and requires a complete understanding of the problem fields it requires an expert programmer to update the rules.

Case Based has gained a lot of use in the field of Legal, Engineering, Medicine, Construction and Military among other areas due to their efficiency in planning, design and decision support capabilities. CBR has proved to be a very effective method of resolving problems where the problems being solved can be featured or classified, described, and the frequency of occurrence of the problem is high. Areas that need to interpret the problem explain the problem and quantify the extent of success and explain the risks involved or that manifested during resolution. CBR must have a framework that must support RETRIEVAL, REUSE, REVISION and RETENTION of cases**. Due to this CBR has become a very successful and useful in fields of medicine where it can be used to treat and manage cases which can be described, are frequent requires a justification, risk analysis and proper interpretation in order to properly plan for the outcomes**. This study focused on use of CBR framework that employed Java technology to aid in the treatment and management of Diabetes.

CBR has also found good application in fields that seek to increase prediction quality, efficiency and that increase the number of solvable problems and the range of accessible resources by augmenting and explaining solutions.CBR has been adopted in areas to implement help desk solutions for customer experience informing and bonding, customer

service, electronic commerce, reasoning and management of knowledge and experience application in health. In health it has been used applied in the areas of image processing, law, diagnosis, design, planning and resource allocation planning and service management fields. Ralph Bergmann (2009) el.tal CBR methods have also been used in manufacturing, plant maintenance, production planning, sales and marketing and also material management's processes. CBR has also been used for configurations in aircraft maintenance and diagnosis process of engine failures, corporate knowledge management, and software quality control it has also been used for molecular biology, computer games and spatial reasoning.

1.1 Problem Statement

Due to changes in lifestyle diabetes prevalence is increasing. Diabetes is a group of metabolic disease characterized by elevated blood glucose levels a condition known as hyperglycemia resulting from problems in insulin secretion, action or both. Diabetes can also be as a result of hypoglycemia which a condition characterized by low blood sugar caused by excessive infusion of Insulin, low carbohydrate intake, unplanned physical activity for patients with long term conditions among others. Insulin is a hormone produced by beta cells of the pancreas which is required by body cells for utilization of glucose which serves as a source of energy.

Long term hyperglycemia is associated with a number of complications related to micro vascular and macro vascular that cause visual impairment, blindness, kidney disease, nerve damage, amputations, heart disease and stroke. There are increasing cases of diabetes worldwide. The common types of diabetes include Type 1& Type 2. Type 1 is prevalent among children and Type 2 is prevalent in adults. The change of lifestyle of patients living with diabetes, physical exercise and insulin pumps coupled with other factors complicates management of diabetes. In addition there is alot of data to be gathered and submitted to the health care professionals for diabetes diagnosis purposes. Some of this data include blood glucose levels, adherence to management plan, patient's diet, among others. This leaves the health professional with a lot of data to process and the effort involved in these processes is huge due to the nature of analytical methods used

in most cases some of them being manual. The methods used involves sieving through multiple number of patients problems which are captured in form of descriptions which include the symptoms like feeling dizzy, vomiting, headaches, unconsciousness, and tests results of the blood glucose levels among others. Based on these factual symptoms an expert eventually interprets this data and reverts with diagnosis plan.

Diabetic cases are common and the problems encountered have similarities depending on the type of diabetes. It is believed that similar problems have similar solutions. Based on the frequency and similarities in this type of problem makes it suitable to be planned, managed and diagnosed by a Case Based Reasoning system. A CBR method makes it possible to capture and process experience in a manner that it can be used for future problem resolution. It implements a 4R method which involves Retrieval, Reuse, Revision and Retention of previous cases eventually making it possible to be trained, adapted and modified to solve new problems based on similarity or features of previous problems.

1.2 Research Objectives

1) To review the viability of the use of previous patient cases, their solutions as a basis for making new decisions when encountering similar cases. To determine whether a CBR framework can be used for clinical decisions support in treatment and management of diabetes.

2) To employ a library to implement a Diabetes CBR system that is used for diabetic diagnosis. To collect previous cases of diabetes and their solutions in order to be used as heuristics for future problem resolution.

3) To employ a tool that implements a CBR concept that supports **retrieval, reuse, revision and retention** of diabetic health experiences in form of **cases (problem-solution pair).** To establish the effectiveness of a CBR application as a tool to deliver health care.

1.3 Research Questions

1) What role does the use of previous experience play in supporting health decisions as far as averting potential risks and diagnosis planning is concerned?

2) How can past solutions be used as answers for current problem? Do similar problems have similar solutions and can diagnosis risk be avoided by use of previous knowledge?

3) Can computer software that manages experience be used to provide justifications and explanations to support clinical decisions?

1.4 Assumptions/Limitations of the Project Were

1) Availability of previous diabetes cases in manual or electronic form.
2) Willingness of health professionals to use the system with sample patients for diagnosis and to assist in reviewing its accuracy in making clinical decisions for diabetes diagnosis, treatment and diagnosis.
3) Authorization to acquire, use and retain sample previous diabetic cases for purposes of this study.

CHAPTER 2

2.0 Literature Review

2.1 Diabetes

According to Centre for Disease Control (CDC) diabetes is a disease in which blood glucose levels are above normal. According to Diabetes Self Management, (2015) Blood for normal people and diabetics is categorized under 3 situations **Fasting**, **2 hours after meals** and **HBA1c** (average over 2 to 3 months) as:

i) **Fasting:** Normal for person without diabetes: 70–99 mg/dl (3.9–5.5 mmol/L).Official ADA recommendation for someone with diabetes: 80–130 mg/dl (4.5–7.2 mmol/L).

ii) **2 hours after meals**: Normal for person without diabetes: Less than 140 mg/dl (7.8 mmol/L), Official ADA recommendation for someone with diabetes: Less than 180 mg/dl (10.0 mmol/L).

iii) **HbA1c:** Normal for person without diabetes: Less than 5.7%, Official ADA recommendation for someone with diabetes: 7.0% or less.

Blood glucose is the main type of sugar found in your blood and the main source of energy. The main source of glucose is the carbohydrates, liver and muscles. The glucose is carried by the blood to all body cells to be used as source of energy. The pancreas produces insulin which helps the blood to carry glucose to the body cells. Sometimes the body does not produce insulin or the insulin produced is either not enough or it does not work properly. This leads to glucose accumulating in the blood because it is not utilized by cells as a source of energy. This eventually leads to elevated blood glucose levels in the blood resulting to diabetes or pre-diabetes. Having too much glucose in the blood causes health problems.

2.1.1 Prediabetes

Predabetes is due to blood sugar being above normal levels but not high enough to cause diabetes. This increases the chance of getting type 2 diabetes and other complications which include heart diseases, stroke, kidney, blood vessel diseases among others. Physical activity, weight loss can delay or prevent type 2 diabetes. Though there are a number of symptoms associated with diabetes such as: slow healing sores, dry, itchy skin, dumbness in your feet, loss of feeling in the feet, blurry eyesight, losing weight without trying, feeling very tired, feeling very hungry, urinating often and being feeling very thirsty the only way to know if you have diabetes is to do a blood test.

2.1.2 Type 1 Diabetes

This type of diabetes (juvenile diabetes) develops often in young people however it can also develop in adults. In this case the pancreas does not produce enough or no insulin at all as result of destruction of pancreases beta cells by the body autoimmune system. Treatment of this type 1 diabetes include taking shots injections of insulin, taking medicine by mouth, health food choices, being physically active, controlling your blood pressure levels and controlling your cholesterol levels.

2.1.3 Type 2 Diabetes

Type 2 diabetes also called adult onset can people at any age including children. People who are overweight and inactive are the mostly affected. This condition begins with insulin resistance a condition that occurs when fat, muscle and liver cells do not use insulin to carry blood glucose to cell for energy. There is an over demand for insulin. Treatment includes using diabetes medicine, health food choices, being physically active, controlling your blood pressure and cholesterol levels.

2.*1*.4 Gestational Diabetes

This type of diabetes develops during expectancy. Hormones are produced that lead to insulin resistance. It can also be caused when the pancreases does not produce enough insulin. This type of diabetes goes away after the child is born. Due to change of lifestyle these cases are common in Kenya. A CBR method of problem resolution is applicable to resolve this type of medical condition because they are common and similar diabetic problems have similar solutions.

2.1.5 Kenya Faces a Rising Burden of Diabetes

WHO November (2014) shows the cost of healthcare in Kenya is an obstacle and complicates treatment. Diabetes has become a growing problem in developing countries, an increase largely driven by a rise in obesity. 80% of an estimated 1.5 million global diabetes deaths in 2012 occurred in low and middle income countries. According to WHO Health (2012) data, 1 % of the deaths in Kenya were attributable to diabetes. Overtime diabetes damages the heart, blood vessels, eyes, kidneys and nerves causing chronic problems and early death.

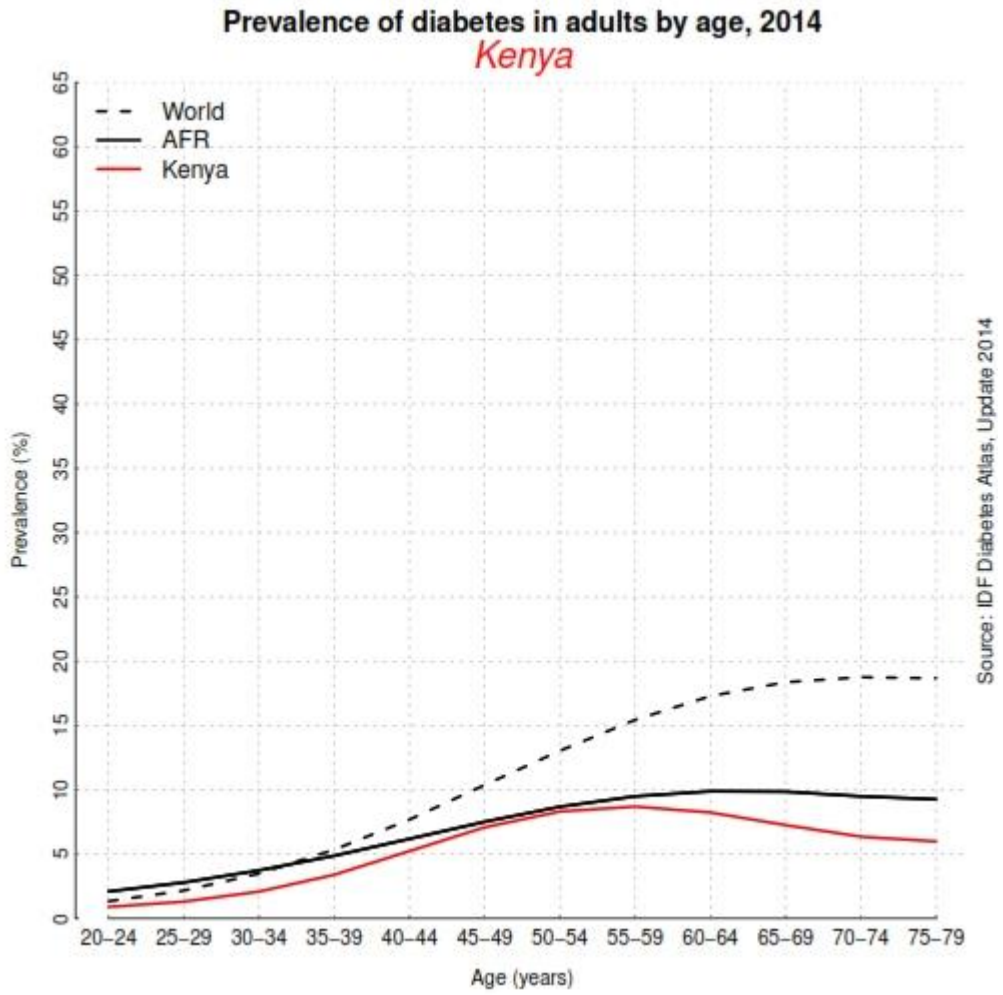

Figure 1: Prevalence of Diabetes in Kenya (source: Internal Diabetes Federation https://www.idf.org/membership/afr/kenya)

2.1.6 Risk Factors and Prevention

Dr. William Maina leader of the Directorate of Preventive and Promotive Health Services in Kenya's Ministry of Health notes that there is rising stress that diabetes and other non-communicable disease (NCDs) such as heart diseases, stroke and cancers are placing on the national health care system. Half of the occupancy of the beds in health facilities is due to NCDs. Half of the deaths reported are due to NCDs problems. Dr. Maina states that this has been driven by a change of lifestyle largely due to consumption of unhealthy food (fast foods) processed foods that are available in the markets today, a decline in physical activity due to motorized transport and as buildings replace playgrounds causing

less engagement in sports and lack of tobacco cessation are among the key causes of diabetes.

Dr. Ngugi also advices that we need to educate medical personnel about the management of diabetes because we do not have enough experts in this country. Most patients are being handled by people who really do not know a lot about diabetes.

2.2Case Based Reasoning

Case based reasoning commonly referred to as CBR (Pure 4Rs systems) or CBR (for hybrid systems) is a problem solving methodology that implements previous experience to solve new problems. CBR has its background in cognitive science, machine learning and knowledge based systems. Presently CBR is established with specific methods and processes together with its application employing those methods for problem resolution in different domains. Ralph Bergmann et.al (2009). This research sought to explore the hypothetical foundations, application development, deployment and application of previous experience to resolve health problems related to treatment and management of diabetes. The concept behind case-base is a repository of previous cases.

A case is ***problem–solution*** situation that has been captured and retained from past experience in a manner that it can be used for future problem resolution with time this problem solution methodology builds enough cases to support learning and problem resolution without having to derive the solution from first principles. A problem solver using case base solves new problems by reuse of solutions from cases in the case base.

2.2.1 Problem Selection in CBR

One of the major assumptions in CBR is that similar problems have similar solutions. To solve a problem similar cases are retrieved and selected and the solutions from the cases are modified or adapted to be used as solution of the new problem. This serves as a suggested solution only. After the suggested problem is used an evaluation is conducted to establish whether the problem has been solved or not. Once the problem has been solved a new successful solution to the problem is found which is eventually indexed and

retained in a case base memory repository eventually resulting into an increase of the CBR competence and thus implementing a learning behavior. CBR can integrate with other A.I fields for the purposes of searching and pattern matching. These fields include cognitive science, machine learning, knowledge based systems, including knowledge representation and reasoning. CBR also to a large extent depends on information retrieval, databases, semantic web and knowledge management. The main objective of CBR integration with other disciplines of AI is purely for experience-based problem resolution.

A framework implemented in this way can find a lot of use in areas of diagnosis, planning, product recommendation and experience management and health. Areas with strong similarity modeling, similarity-based retrieval and adaption are good CBR application fields.

2.2.2 Case Representation Knowledge

Knowledge in Case based reasoning is represented as textual, structural and conversational. In structural representation cases are represented to a common structured library. Cases are restricted to represent experience that can be expressed with this vocabulary. In structural representation the features associated to a given case are grouped as flat attribute-value pair in an object-oriented manner as graph structures or set of predicate logic language in a textual CBR cases are represented as free text i.e. strings. This is useful where we have a large collection of text support documentation and the CBR system has a way of searching for appropriate text based on experience. In a conversational CBR a case is represented through a list of questions that vary with cases.

2.3 The Main CBR Conceptual Framework

Aamodt and Plaza, (1994) states that the core concept of the CBR is a four step process which involves a) retrieval b) reuse c) Revision d) retention which is organized around the CBR knowledge. The knowledge of CBR is represented in a four phased manner. The process begins by selecting one or several similar cases from the CBR repository by use

of pattern matching techniques. Based on the nearest neighbor method we then re-use a solution from the selected cased. A modification phase may be necessary to proof the solution in a real world situation and possibly amended or enhanced by a health professional. The last phase of CBR is the capture stage which involves mechanism of indexing and retention of the successfully evaluated cases into a knowledge base. See Figure 2. for illustration of CBR conceptual framework.

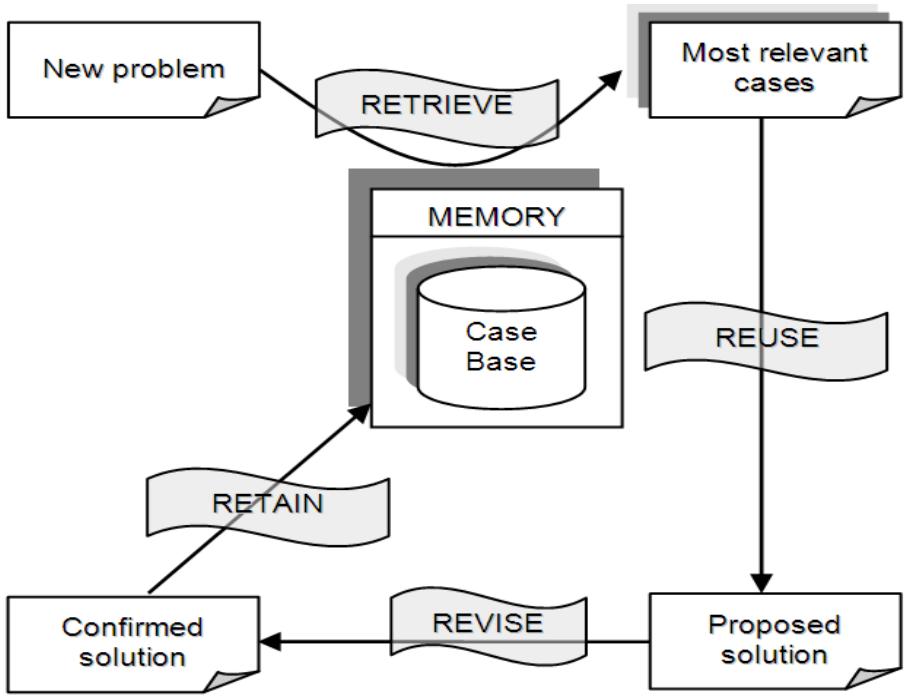

Figure 2:CBR Conceptual framework. (Source: Aamodt and Plaza , (1994)

2.3.1 CBR Composition

CBR is a problem solving methodology where previous cases are structured in a manner they can be retrieved, reused, revised and retained for problem resolution. A current or new problem referred to as a target case is solved by implementing a solution that is revised from that of the most similar retained case.

A case comprises of:

a) Problem description: This refers to definition of the problem that requires to be solved. In Problem description we analyze the features of the problem that aids in the retrieval of most similar cases.
b) Problem solution: The derived solution which only acts as a proposed/suggested solution is subject to evaluation.
c) Results can be a success or a failure.

CBR frameworks have the capability to retrieve a stored case that matches a problem description. The problem description forms the new case. An algorithm (input the algorithm) is used to calculate the similarities and differences between the two cases. The problem description is used to develop a problem solution. The developed problem is then evaluated in a hypothetical or empirical environments and the outcome used to revise the solution if a new experience is gained that can be useful in future is retained as a new case and index are updated.

2.3.2 Problem Structuring and Analysis Mechanism

Trondheim (2006) states that the case description can be either described in technical or functional terms. When a complete problem description may not be available this can sometimes lead to ambiguous description which can be eliminated by promoting a dialogue between the user and the retrieval. This method helps the user construct a problem description incrementally through a question answer mechanism.

2.3.3Problem Representation and Retrieval

For effective retrieval the users must be in a position to describe the problem that is being resolved. The problem feature must be captured in way to be able to identify the similarities and differences between the problem being solved and problems stored in the cases. One of the methods of describing the problem is to include a knowledge intensive conversation CBR. This CBR methodology implements the general domain knowledge to enhance the quality of retrieval. This method aids in feature interpretation, retrieved case

ranking and case classification and abstraction. One of the key processes of an effective CBR is having capability to integrate within itself an efficient retrieval model.

Sometimes a problem can be represented as feature value pair. The questions are formulated based on these rankings information gain metric (IGM) which refers to how well a feature separates a case based on the derived solution another way of ranking is by use of occurrence frequency metric where questions are ranked according to their frequency of appearance in the problem description part .Importance metric weight which is concerned with how dimension is achieved, in that not all features are relevant and equally important in similarity calculation. Similarity variance metric is an information measure based on the similarity each case retrieval is based on some similarity values between the stored case and the retrieved case based on some similarity variance from the rest of stored cases (Trondheim, 2006).

Based on the ranking criteria methods for instance information metric is suitable where much of the data is not missing whereas occurrence frequency metric is applicable we have scanty data.

2.4 Reasoning in Health Care

Reasoning undertakes the process of thinking and cognition. It also pertains to thought process, regrouping of ideas and how experience is processed in order to reach a rational conclusion. Earlier on experts used to reason manually in order to solve problems encountered. With time a need arose to automate reasoning by use of soft computing methods. Effective reasoning automation lies in capability to describe and present problem experienced. According to Maggi Banning (2007) Decision support is a hallmark process involved in patient care management and diagnosis. This process involves the ability to assimilate and analyze health care evidence, ranked according to its efficacy and application to certain groups of patients. This pertains to the application of knowledge (derived from reasoning based on the ability to describe or present a problem) to a clinical situation to develop a solution. **When effectively automated reasoning becomes the hallmark of expertise.**

Reasoning is used at all levels in health care to inform decisions about the level of care given to patients. There a number of thinking concepts or frameworks that are applied to the strategies of problem resolution. One of such strategy is the think aloud strategy. A good example of health reasoning is clinical reasoning which has different forms. One of these forms is problematic reasoning where a problem is identified by its influential/causal factors and processing the solutions that may be used to diagnose the problem. This approach can be used to identify health diagnosis and help in planning and implementing interventions by novice associates/experts.

Another form of health reasoning is theoretical reasoning which begins inductively and considers a hypothesis and deductively arrives at a conclusion (Carr, 1981). Practical reasoning is also common in health delivery and it terminates once the action taken has achieved the diagnostic objective e.g. the result of patient care plan (Greenwood and King, 1995). On the other hand operational reasoning involves the elimination among many choices and viewpoints until the best solution has been reached. Operational thinking can be used to debate the suitability of research method and data analysis. These methods are used to develop realistic and measure goals with respect to health care management.

All these forms of reasoning can be used to deliver various healthcares to patients whose health status has been changed due to sustained issues. Dialectic reasoning involves analyzing problems in a holistic manner. That the whole is the sum of parts. Opposing factors are explored and then combined in order to analyze the problems. The aggregate of factors into a mono resolution is more powerful than isolated assessment of factors. Indialectic reasoning the weaknesses and strengths of the problem is the most important when it comes to informing conclusions.

Steps involved in health reasoning include making expert judgments, the quality of evidence based information to support problem resolution and consideration of whether the levels of evidence available is adequate to commission decisions on diagnostic and treatment options relevant to health care requirements of the patient (Hieggs et.al, 2001).

2.4.1 Reasoning Strategies

Metacognition is a thinking strategy where one thinks about thinking .It is the control of cognitive process and the evaluation of thinking outcomes in regard to the a learning situation. It is a design of how we plan, control and oversee our thinking process and activities in order to achieve a goal or objective in this research a diabetic patient problem resolution. During this process the medical experts or professional uses inductive logic (from specific to general i.e. the causal factors, symptoms) to assemble and evaluate patient information and supportive evidence before making professional judgments on delivery of health care.

In health thinking there is a relationship between a professional's cognition (thinking) the problem explanation and description and the environment of the situation where cognition is applied (Maggi ,2007).Making judgments on the use of evidence based on **past experience** but also on underpinning knowledge, judging patient's situation, hypotheses generation, diagnostic reasoning and reflection forms part of the multiple cognitive processes needed for health care management (Pesut and Herman, 1992).Health reasoning is a poorly defined construct which has been assessed using limited measurement tools. According to Farrell and Bramadat (1990) health reasoning skills employed by health professionals have been labeled **as problem solving, health judgments, information processing, diagnostic reasoning and decision making.**

The role and importance of experience in patient problem resolution is shown by a number of studies conducted to evaluate students and qualified health professionals on ability to make decisions. The results of study reflected insufficient time provided for students to assimilate and information and apply new theory to health examples i.e. Students exhibited longer time to resolve issues compared to their more experienced counterparts. Several frameworks have been used to collaborate in decision making and service organization in responses to important patient's needs interpretation signals. The physiological assessment of the patient is dependent on technology and precise information provided by these technologies (Banning, 2007).

2.4.2 Intuition

Rew and Barron (1987) states that intuition is an understanding of situation event as a whole that cannot be logically explained. Schrader and Fischer (1987) also refers to intuition as type of knowing that is unbidden and is described as a 'gut feeling' or immediate knowing of something without the conscious use of reason. The problem is explained by establishing the relationship between the causal variables in order to offer argumentation. Intuition is an effective method that supports expert decisions however it is dependent on the situation of application. The source knowledge of intuition is largely dependent on one's personal knowledge and experience but also related to the complexity of the judgments to be made and time available to make the decision. According to Gilhooly, (1990) decision making may involve identification of similarity and pattern matching of prototypes from earlier observations to generate a diagnostic abstraction or hypothesis and aggregation of information together to form concrete patterns which are retained in a long term memory (database) to inform reasoning.

2.5 Case Presentations in CBR Systems

Think aloud is a qualitative tool (problem explanation) that is used to evaluate cognitive processes used in health reasoning. It involves gathering verbal data about a cognitive process important to problem solving. Kuiper's et al., (1988) the think aloud process has been used to collect accessible information about thinking processes using nursing and medical clinical scenarios. However this approach is proves difficult for most novice health professionals. This may be from lack of training in clinical reasoning skills.

Simulations by use of system (case based system) may be used to present lifelike situations however their use has been criticized for their inadequacies in presenting to map the complexity and unpredictability of the real-life setting and the thought process that practitioners utilize in natural situation. Connection, evaluating, judging, planning and explanation are some of the cognitive operators that are used to describe health care. Hypothesizing by use of direct thinking, inductive logic and metacognition form a key part of this thinking process.

2.5.1 Health Data Information Analysis Methods

Protocol analysis is a common method of data analysis used to analyze findings from the case presentation. Assertion analysis is used to reason statements offered, like create concept clusters for health reasoning. Script analysis is implemented to give highlight cognitive process and thinking strategy used by professionals. Phase analysis is used to capture the vocabulary of concepts and isolate information**.** Medical heuristics is used to consolidate patient information and apply knowledge gained from experience and education. Heuristics involves pattern recognition, judging the value, providing explanations, forming relations and drawing conclusions. There are six concepts involved in this plan, rationale, status, test, treatment and value. These concepts move reasoning forward and are linked to specific assertions; cause and effect relationship, declarative or statements of facts, evaluative judgments of significance and anticipative expectation of action. These reasoning processes and strategies enable professionals to quickly analyses patient's information, evaluate its significance and formulate alterative actions.

This supports that information processing is the underlying conceptual framework for health reasoning where by experienced professionals combine individual knowledge and experience to merge information represented into manageable concepts. This also includes schema models to form mental models for problem resolution and manage care. Prototype formation using the above methods is the hallmark of health reasoning (Benner et al., 1996).Ferrario (2004) views that prototypical modeling reduces cognitive processing time and result in heuristics shortcuts which allows medical professionals to progress from rule based thinking and step by step analysis to more focused reasoning method which avoids cognitive strain. The importance of use of cognition to aid in making professional judgments and evaluating the quality of evidence to solve problems and make diagnostic and patient management decisions is keying delivery of health care

2.5.2 Similarity Theory in CBR.

Ralph Bergmann et.al (2009) vocabulary (Ontology) representation of knowledge forms a key method of knowledge and experience representation. This includes the structure, similarity matching and modification knowledge it also includes the problem feature

attributes, classes, values, relations and data types. Similarity in CBR is key as it used for case selection and matching. Some of the methods used in similarity include inverse Euclidean or hamming distances. A more complete similarity method is to use the encoding of the knowledge domain. Ralph Bergmann el.at 2009 formalizes similarity as a function sim: PxP -> [0, 1] which compares two problem features from P and returns a similarity assessment as a real value from [0, 1] a high value confirms a high similarity. For a new Problem P a case $c_1 =(p_1,s_1)$ is preferred over $c_2 =(p_2,s_2)$ Ralph concludes that $c_1 >_p c_2$ iff sim $(p,p_1)>$ sim(p,p_2) the similarity based retrieval lists c_1 before c_2 and if the utility s1 for solving p is higher than utility s2 for solving p case c1 should be preferred over.

In CBR retrieve one or more of the cases are selected from the case memory. The cases with highest feature similarity are retrieved. As the number of cases grow efficiency is comprised however use of indexing re-organization, case retrieval nets and discrimination networks improves the retrieval process.

In CBR a new or current problem is solved by re-using the solution in a previous case. The copied solution is subject to evaluation to ascertain whether the problem has been solved. If the problem is resolved the case indexes are updated and no need to retain this case as it already exists. However if the problem has not been solved the solution is adapted or modified to suite the new problem once successfully tested the changed solution is retained as a new case this way a CBR implements a learning behavior. The experience gained from solving a new problem becomes available for reuse to solve future problems.

2.5.3 Highest Level of CBR Abstraction

Juan el.at (2013).The highest level of abstraction of CBR is described by a cycle which involves four processes which are as follows.

1) Retrieve/selecting the most similar case or cases.

2) Reuse the information and knowledge in that case to solve a problem this involves copying a past solution.
3) Revise the proposed solution this process involves the modification or update of the copied solution to fit the current problem. The revision part may involve an expert intervention.
4) Retain the experience likely to be useful for future problem solving this may include indexing for quick retrieval where we have a large number of cases is searched.

CBR cycle highest abstraction level is illustrated in figure 3

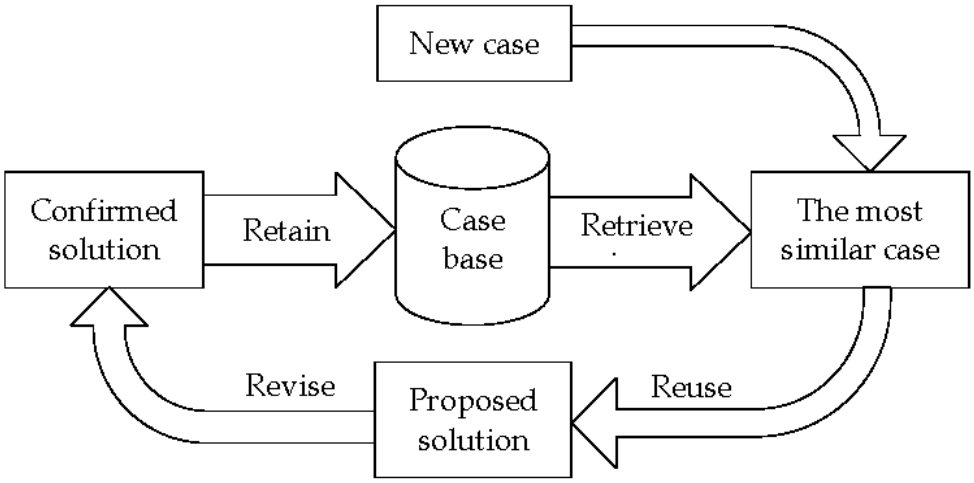

Figure 3: CBR highest abstraction level. (source:http://www.intechopen.com/source/html/43544/media/image7.png)

2.6 CBR Applications

2.6.1 Legal Field

CBR is a recent field of artificial intelligence which has been very effective and successful in problem resolutions. One of the initial works has been in the legal field where several systems have been deployed to assist in making rulings. Some of the system include: **Hypo** is a case based reasoning system that deals with trade secrets Hypo was developed by Kevin Ashley and Edwina Rissland at the University of Massachusetts it does analysis of problem situations and retrieves necessary cases from it CBR memory

to form legal judgments. **Kowalski's System** is a CBR implementation in areas of malicious prosecution. HELIC-II a legal system for penal code, **JUDGE** is a CBR that models sentencing of criminal done by real –life judges he interviews what the judges would do in some scenarios and then form hypothetical cases to build a CBR reason. **IKBALS** works in the field of compensation law.(Sima S., 2013)

2.6.2 CBR Application in Health Field

CASEY is an application developed at Massachusetts Institute of Technology (MIT) it does analysis of patients with heart diseases and produces a diagnostic explanation of the symptoms of the patient condition. A proton has been applied in field of clinical audiology. BOLERO diagnosis the causes of pneumonia. SHRINK is an application modeled from experience in diagnosing psychological problems.(Sima S.,2013)

2.6.3 CBR Application in Engineering

Archie is applied in architectural designs and plans. It gives architects case base of designs created by other architects and helps in factoring out how problems can be solved based on previous cases. It is used in high level abstraction. CADSYN programmed by Maher & Zhang is used in field of structural design.

Simply CBR has gained wide use in the help desk support computing for diagnosis of computer and software problems, communication networks for diagnosis of network faults. CBR has also been widely used in manufacturing designs. In Credit lending CBR has been used to assist in making credit decisions, SCAN has been used in finance to help novice auditors in evaluating controls and proposing audit recommendations.CBR in finance has been used for bankruptcy prediction. In food industry it has been used for meal planning and coming up with new types of recipes. CBR has been used in airport scheduling to come up with complex schedules for allocation of resources used for large scale airlift operations which involve thousands of individual tasks movement of cargo and personnel from one location to another. CBR has also been widely applied for route finding in Singapore by R-Finder. Material handling system for design and automatic assembly involving centrifugal feeders and automatic vibrators. Telephony allocation of

resources by network providers has employed CBR systems. AIRQUAP in Environment has been used to predict the level of air pollutants in Athens Greece. EPAION has been used for flight fault diagnosis. This indicates how successfully CBR has been adopted in multiple problem resolution.

CHAPTER 3

3.0 Methodology

This chapter highlights the research methods that were followed to achieve the objectives stated in section 1.3.It includes methods of data collection that were used for this project. This involved a collection of previous diabetes cases from a health facility. With the help of medical experts the data was formatted in such a way that it was useful to capture the features of a problem and how it's solution was returned. This process informed the creation of a diabetes concept in the system , the fields and their data types which comprised of the features in order to have a complete representation of a problem – solution pair referred to as **cases**.

The following are the activities that were done for this study.

1) A formative evaluation to determine whether this study was justified. The questions stated in section 1.4 were categorized in such a way that the results identified whether the project was feasible.
2) Data and Information sources and collection tools included data for diabetic cases the problem description and solution to these problems.
3) Formatting and cleaning of the data to represent diabetes problem features and formats of solutions to be returned. The output of this process lead to a case which comprised of two parts
    i) A diabetic problem description.
    ii) A solution description.
4) A case based reasoning application development by use of java workbench specifically JCOLIBRI framework workbench
5) Design of the system.
6) Implementation of the system and deployment.
7) Development of the test cases to demonstrate the following. Retrieval, reuse, revision & retention.
8) Evaluation of the test cases

9) Summative evaluation to determine the outcome of the results of accuracy on whether A CBR tool can be used to diagnose, treat& manage diabetes based on the number of cases tested.

The execution of activities to achieve the specified objectives are enumerated in table 1 below.

Table 1: Activities that were executed to realize objectives

No	Goal	Method of achievement.
1	To test the acceptability of previous solutions as solutions for new or current problems	Administered a questionnaire to the medical experts to get their opinion.
2	To determine whether CBR framework can be used for clinical decisions support in treatment and management of diabetes	Developed an application that implements CBR framework to support CBR cycles. The system used JAVA Workbench jCOLIBRI framework tool to implement a CBR system that was used for diabetic diagnosis
4	To collect previous cases of diabetes and their solutions in order to be used as heuristics for future problem resolution.	Gathered existing cases of diabetes from a health facility. The case was grouped into problem-solution pairs that was stored and retrieved by use of some similarity functionality to inform diabetes medical interventions.
5	To determine whether a CBR methodology can be achieved using existing technology	Employed a tool that implements A CBR concept to support retrieval, reuse ,revision and retention of health experiences in form of cases (problem-solution pair)
6	To establish the effectiveness of a CBR application as a tool to deliver health care.	Conducted a summative evaluation survey to determine the number successful cases treated and management by a CBR

		applications

3.1 Research Design

The approach taken in the study was chosen based on the believe that similar problems have similar solutions. A new solution was solved by availing a previous problem description. Based on some similarity formula the most similar cases were selected. And the most similar case retrieved by use of the nearest neighbor was used to solve a new problem.

3.2 Data Collection Methods and Tools

The source of data for this study involved gathering previous cases of diabetes from a health facility or from other authorized electronic sources. It included collecting and gathering this data and grouping it into a pair of problem solution. The form could either be in manual or electronic form. The data was cleaned and features extracted from the data. The features were generated in such a way that it was possible to describe a diabetes problem. The solution format was taken into consideration. The data collected was stored in either a database or text file .The columns or features describing the problem were comma delimited and rows separated by semicolons for textfiles. The features defined were dependent on the type of diabetes. The features extracted here determined the similarity functionality that was defined to facilitate indexing and retrieval of the cases. A list cases collected was the reasoning and heuristics behind the concept.

3.2.1 Similarity

Juan (2008) states that the central problems that all CBR methods have to deal with include cycles of problem resolution that involves to identify the new problem situation, search for a previous similar solution and copy that solution to suggest a solution to the current problem, evaluate the proposed solution and update the system by learning from this experience. How this is done, what part of the process that is focused, what type of problems that informs the methods, varies considerably and that no specificity of used technology. However this study sought to use **jCOLIBRI framework to** implement this 4R methodology.

3.2.2 Retrieval

The retrieval obtains the most similar cases given after a query is issued. The retrieval is computed based on a nearest neighbor (NN) retrieval formula. This method performs a nearest neighbor scoring based on the source and target problems. Global similarity and local similarity is utilized in order to arrive at the most similar case or cases. The Global similarity includes functions such as the mean and the local similarity has functions such as the equal, numeric distance etc. The NN scoring uses global similarity function for features/attributes local similarity and weighted similarity. The similarity method was dependent on the data type of the attribute this could be applicable to types such as the integers, strings etc. Most similar cases are scored based on the based on the scoring according to their similarity with the posted query. The k-NN retrieval which is based on the top K selection and nearest neighbor is the most common retrieval function.

*3.2.**3** Reuse*

The reuse cycle adapts the solution of the retrieved cases to the needs of the query. This method shall be concerned with **direct attribute copy** method which copies the attribute value to an attribute of the case or a performance of **numerical direct proportion** among features of the query.

After adaption of the cases the CBR system proposes these as the suggested solutions of the current problem which are subject to review by a medical expert.

3.2.4 Revision

In this cycle the suggested solution was tested for success in real application situation or tested by an expert. The cases were modified if the solution failed. This method provided a mechanism to adapt a case instance by assigning a new ID to the case being revised if a need for retention arose.

3.2.5 Retention

When a suggested solution is proved to be successful what happened next was to have a way to retain it in a case memory for future problem resolution in this way a CBR application using CBR methods implemented learning? The cases were stored in a persistence memory which included a database or cached storage in the memory which was committed on application shutdown.

3.3 Execution of Methodology

3.3.1 Gathering of Previous Diabetic Cases Data

This process involved the gathering and organization of previous cases of diabetes. The list was provided by a health expert or extracted from credible sources in order to form an initial knowledge base. The list was then incremented as new cases are retained for future problem resolution.

3.3.2 Data Preparation for Feature Definition Mapping

After collection the cases were structured in such a way to describe a diabetes problem. This involved forming and representation of the case. The attributes with their corresponding data types were captured and subsequently represented in table structures for creation and for containing instances of the cases.

3.3.3Solution Mining

This step involved the retrieval of solutions that was copied to achieve the objective. Once the solutions were retrieved an expert reviewed them for suitability to resolve the problem at hand. Once a decision was attained the solution was copied and used for the new problem. The solution can be amended or used without alterations after which it was retained for future resolutions.

3.3.4Evaluation of the Cases

Once the system is developed, implemented and deployed. An evaluation was conducted to determine the number of diabetes cases resolved by the application. The solutions were reviewed by an expert to ascertain whether the diagnosis provided has succeeded or failed.

3.4Cycles of Execution of CBR Methodology

3.4.1 Recycle

During the recycle the cases were read and organized into a case base .All the necessary database connections were established during this point. If this process failed exceptions were thrown and the application terminated with a failure message

3.4.2 Cycle

At this stage the parameters passed in the query were executed and passed into the case base. The four processes of CBR executed to retrieve the cases with the most similarity. Based on the judgment of an expert the solutions retrieved was reused and retained if need be for future usage.

3.4.3 Post Cycle

The last cycle shall involve the commission of all the cases and data in memory this process was necessary to support persistency for future retrieval.

3.5 Cases Database

The case base was stored in a database. The database used was an RDBMS or a text file as JCOLIBRI uses internally the hibernate as the middleware technology. Hibernate supports high performance objects and relational persistence and query services. It also supports Jboss, J2ee server supporting different databases and xmls files. By implementing hibernate JCOLIBRI allowed the use of RDBMS databases.

3.6 Diabetes Feature Description and Representation

A set of attributes that describes diabetes was captured. These attributes were used to generate the diabetes cases structure. The attributes were represented by use of data objects which included both typical data types such as integer, real, Boolean etc. or defined types. This process involved the representation of cases (diabetic instances) as java objects referred to as java beans with get and set methods. With jCOLIBRI it was possible to create cases as normal java classes .This capability simplified programming, debugging and configuration of CBR applications by use of frameworks you can generate GUI and automatic persistence.

3.7 jCOLIBRI Framework

Juan el at. (2008) a framework is a set of objects that embodies an abstract design for solution to a family of related problems. JCOLIBRI is a java framework that implements the Object oriented architecture for building CBR applications. JCOLIBRI has two versions.

3.7.1 Version 1

This is a formal release of the framework. It has GUI capabi*l*ities that guides user in the design of CBR system. This is a black box and it is limited in capabilities.

3.7.2 Version 2:

This is a latter implementation that follows a modern architecture it has two approaches one oriented to application developers aimed for future objectives it is a white box solution.

jcolibri framework architecture solves many problems related to case representation, management of metadata and development problems. Figure 4 below illustrates the jCOLIBRI architecture layers.

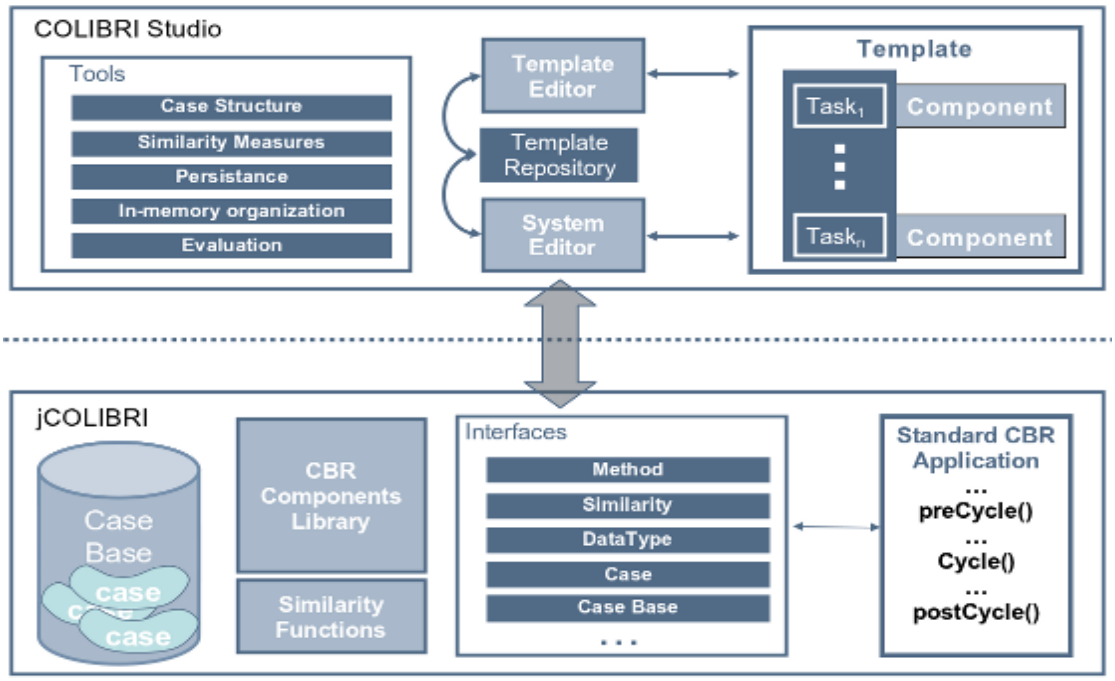

Figure 4 :Jcolibri framework architectural layers (Source jCOLIBRI2 Case Based Reasoning Framwork Documentation).

Advantages of Choosing jCOLIBRI for Case Based Reasoning

1) jCOLIBRI is a framework that does not complicate explanation capabilities.

2) It uses versions of JDK java compilers that are open source which provide capabilities such as support of generality, computation costs and availability of knowledge.

3) It supports the 4Rs of CBR methodology which include Retrieval, Reuse, Revision and Retention.

4) It provides the necessary GUI features which simplifies development processes and definitions of projects, concepts, attributes and similarity functions.

5) It is a framework tool that supports transparency explaining why the result was achieved, justification explaining why a result is valid, relevance explaining why the result achieved is important and a concept that explains the meaning of a term. JCOLIBRI support learning.

6) Supports fast prototyping.

7) Integrates in CBR functionality and leveraging current technologies.

Figure 5shows a high level abstraction schematic of how the diabetes CBR application functionality was attained.

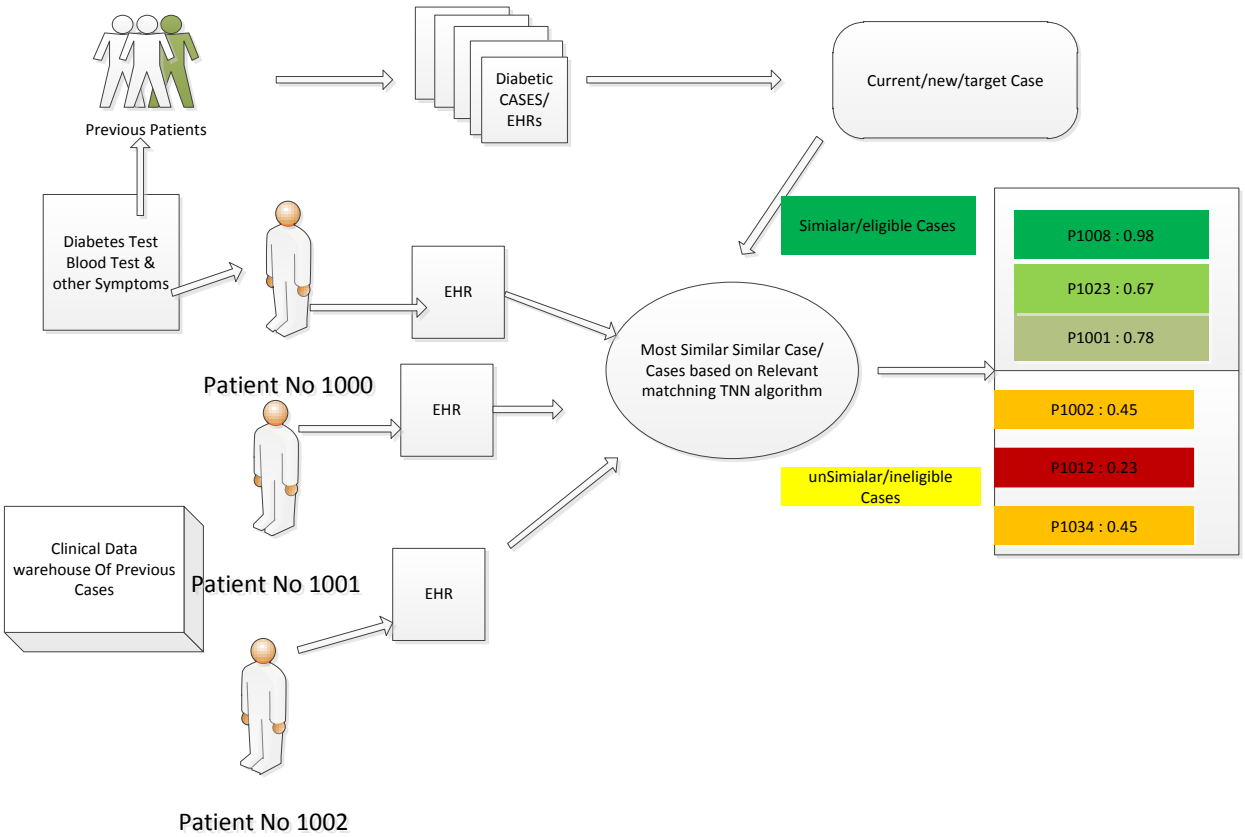

Figure 5: Diabetes CBR application high level work flow.

3.7.3 Core Function of jCOLIBRI

The primary function included similarity matching that computed the distance between 2 or more cases in a case base which acted as the memory for the CBR. Similarity determines the results of retrieval and plays a very important role and therefore was key to successful implementation and actualization of the proposed application. Vocabulary was used to define the domain knowledge and definition of structures and inheritance. The structures allowed for the explanation of the features. The vocabulary provided insight into the actual data types thus validating the allowed values. The ontology of the cases was comprised of the vocabulary defined the cases which to a large extent defined the adaption. It contained the terms, attributes and concepts and the adaption Knowledge that was applied where the case retrieved does not exactly match the current problem and only a nearest neighbor was available for modification to fit in the new problem. This supported module that facilitated the creation of a project, definition of similarity, concept creation, and creation of concept features and support of SDK APIs that included the compilation of classes that assisted in reasoning.

3.7.4 jCOLIBRI Modularization.

The jCOLIBRI is modularized to include the following modules and objects that supported Diabetes CBR concept for problem resolution.

1) Contains objects that represent primary functions of a CBR application that include domain model, Case base, functions to support similarity and retrieval procedures.

2) Code that is specific to actions that process observable cases.

3) Contain JAVA objects for definition of default case base objects.

4) Object with capabilities to define and explain more information regarding the jCOLIBRI concepts.

5) Has classes for the basic definition of the projects model.

6) Retrieval algorithms that are implemented of abstract class of retrieval engine and were used with retrieve cases with corresponding similarity.

7) Classes were used to maintain similarity functions for attribute descriptions and concepts.

8) The project contained classes for project enumeration specifying configurations.

9) Contain classes that handled import and export of relevant CBR application data.

10) Methods used to define similarity that constitute weighted sum and local similarity The methodology employed functions that constitute a weighted sum of all local similarities (attribute similarities) of a concept that forms global similarity measure of a given concept. There a number of weighted sum functions that comply with different applications .jCOLIBRI allow one to use similarity function which is modeled.

CHAPTER 4

4.0 System Design and Implementation

The system was designed using object oriented technologies. The core objects are coded using hibernate framework. This framework helps in mapping the problem description using xml file and mapping of the solution. The system includes a database connection xml that maps to the database. The frontend was attained by importing and implementing the jCOLIBRI objects.

4.1 System Description

The system has modules that implements a 4R methodology stated earlier in the objectives. The core functions are:

- A query dialog interface.
- A similarity configuration dialog interface.
- A revision dialog interface.
- A Retention dialog interface.

The methodology captured in the system was a transformation of how a doctor solves a given medical condition by having a dialog with the patient in an attempt to gather the characteristics of a condition from the explanation and interaction. Once the characteristics are attained the description was mapped into a known medical case. The system provides similar types of functionalities and interfaces to facilitate extraction of the characteristics and similarity matching of experienced problems together with their solutions. Figure 6 illustrates a use case model for the case based reasoning (CBR) application. The use case highlights the roles of super users and users and the application boundaries.

4.1.1 Use case model

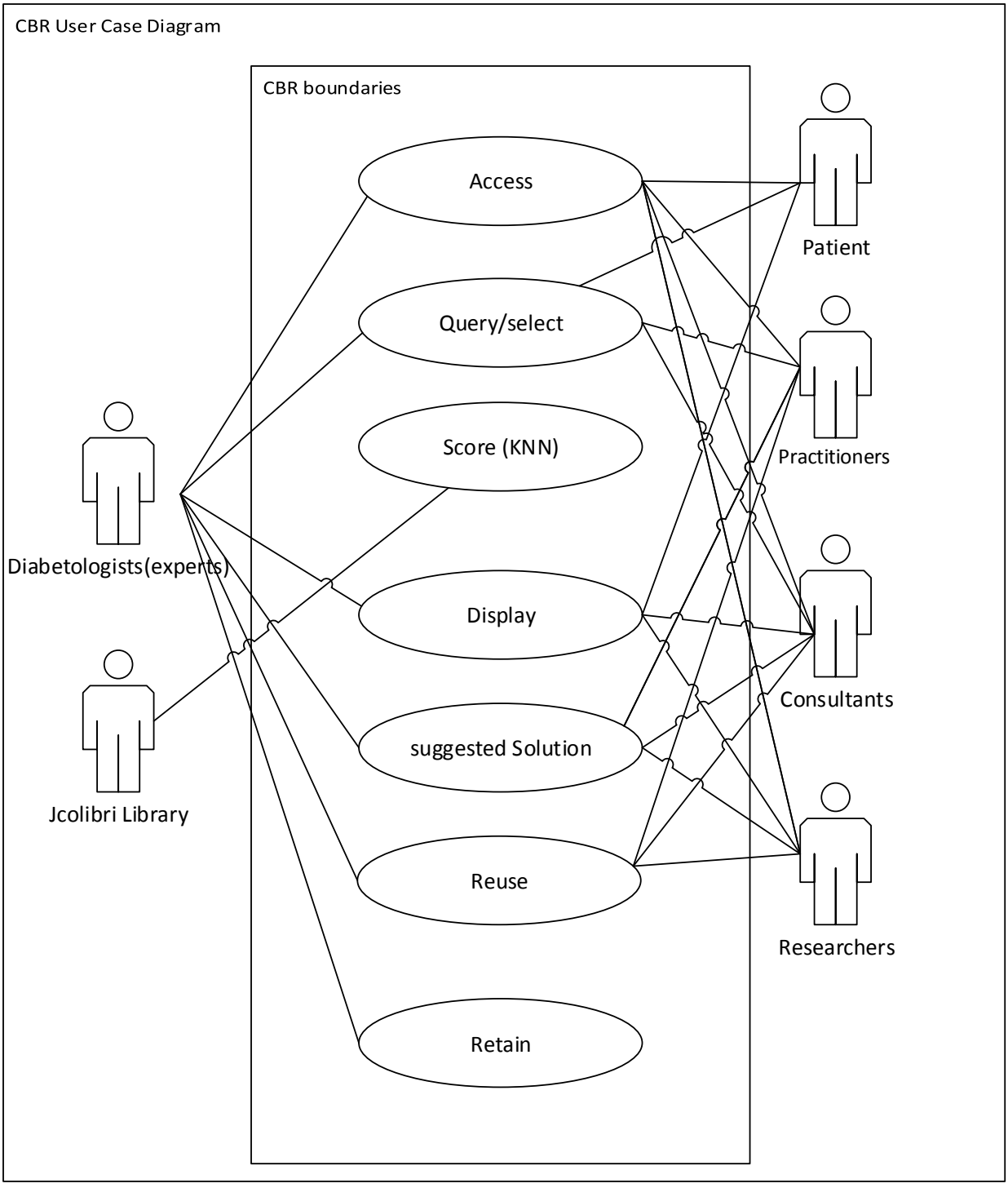

Figure 6 : Use case logical model diagram showing the entities and their relationships

4.1.2 Configure Query Use Case

Table 2 below illustrates the 1st cycle of the case based reasoning (CBR). The 1st cycle provides the flow necessary to define the problem.

Table 2: Configure Query Use Case Table

Use Case Id :	UC1				
Use Case Name:	Configure Query Dialog				
Version:	Version No	Created By	Date Created	Supervised By	Date Updated
	1.0	Mark K. Karani	Tuesday, September 1, 2015	Peter W. Wagacha	Tuesday, September 1, 2015
Actors:	Medical Experts & Diabetes Treatment &Management CBR System.				
Description:	The Configure query functionality provides a medical expert with a dialog to assist in capturing the symptoms & tests results of a patient.				
Precondition:	1.The Capture Query function must be available in the interface				
Trigger:	1. The User launches the CBR application which presents a configure query interface.				
Basic Course:	Procedure to capture the attributes of diabetes using the query dialog. 1. Launch the CBR application using the application icon. 2. The System must display **the configure query** interface to capture the diabetes details 3. The medical expert keys in the attributes of diabetes using the widgets provided by the interface. 4. Upon Successful entry of attributes the system moves on to the next dialog of **configure similarity** by clicking on the set **query button**. 5. End of configure query function use case. The **1st R** cycle is				

	completed.
Alternative Paths:	1. The medical expert can choose not to complete the 4 R cycle and exits the application by clicking on the exit button. 2. The system exits end of use case.
Post Condition:	1. The query details are stored in the application memory and used for setting the similarity in the **2nd R** of CBR cycle
Exception Paths:	1. a) If the expert enters invalid data the data in the field is reset to the default.
Includes:	None
Priority:	High
Frequency Of Use:	High
Business Rules:	Configure Query: 1. The query must include all the ontology for diabetes. The problem description of diabetes.
Special Requirements:	None
Assumptions:	None
Process Owner:	Medical Expert
Notes and Issues:	None

4.1.3 Configure Similarity

Table 3 highlights the process flow including the business rules, pre and post conditions needed to execute the similarity functionality of the system.

Table 3: Configure similarity use case

Use Case Id :	UC2				
Use Case Name:	Configure Similarity Dialog				
Version:	Version No	Created By	Date Created	Supervised By	Date Updated
	1.0	Mark K. Kiragu	Tuesday, September 1, 2015	Peter W. Wagacha	Tuesday, September 1, 2015
Actors:	Medical Experts & Diabetes Treatment &Management CBR System.				
Description:	The Configure similarity functionality provides a medical expert with a dialog to assist in setting the weight of each symptom and attribute.				
Precondition:	1.The configure Similarity function must be available in the interface				
Trigger:	1. The User clicks the set **query button** which pops up the **configure similarity interface.**				
Basic Course:	Procedure to set similarity and weight diabetes attributes using the configure similarity dialog. 1. Launch the configure similarity form using the set query button 2. The System must display the **configure similarity** interface to allow setting of the attributes weights. 3. The medical expert sets the weight of the attributes using the buttons provided by the interface. 4. Upon Successful setting of the weights the system moves on to the next window listing the scored cases after clicking the set similarity configuration button. 5. End of configure similarity function use case. The **2nd R** cycle is completed.				
Alternative Paths:	3. The medical expert can choose not to complete the 4 R cycle and exits the application by clicking on the exit button.				

	4. The system exits end of use case.
Post Condition:	1. The scored cases are listed and displayed together with their global similarity and local similarity ranging between 0 < X<1.
Exception Paths:	1. a) If the expert enters invalid data the data in the field is reset to the default.
Includes:	None
Priority:	High
Frequency Of Use:	High
Business Rules:	Configure Similarity: 1. The weight of each attribute is set by a medical expert.
Special Requirements:	None
Assumptions:	None
Process Owner:	Medical Expert
Notes and Issues:	None

4.1.4 Retrieved Cases

The 2rd cycle business function of CBR to retrieve the matched case/cases is illustrated below in table 4. The retrieved cases will help in diabetes care decision making.

Table 4: Retrieved cases use case

Use Case Id :	UC3		
Use Case Name:	Scored cases Dialog		

Version:	Version No	Created By	Date Created	Supervised By	Date Updated
	1.0	Mark K. Kiragu	Tuesday, September 1, 2015	Peter Waiganjo	Tuesday, September 1, 2015
Actors:	Medical Experts & Diabetes Treatment &Management CBR System.				
Description:	The retrieved cases functionality provides a medical expert with a dialog to display a list of the scored cases based on a similarity function. The k parameter indicates the number of case to be displayed.				
Precondition:	1.The retrieved cases function must be available in the interface				
Trigger:	1. The User clicks the set similarity button to launch the interface for ranking the cases.				
Basic Course:	Procedure to display scored the attributes of diabetes using the query dialog. 1. Launch the retrieved cases interface by clicking on the set similarity button 2. The System displays the **retrieved cases** interface to display the scored cases. 3. The medical expert sees a set of retrieved cases scored based on a nearest neighbor configuration. 4. The number of cases retrieved was based on the input value of cases to display. 5. The medical can scroll through each of cases by use of the pagination buttons. 6. End of function use case. The **3rd R**cycle is completed.				
Alternative Paths:	5. The medical expert can choose not to complete the 4 R cycle and exits the application by clicking on the exit button. 6. The system exits end of retrieved cases use case.				

Post Condition:	1. The interface must show the cases that are candidates for reuse and revision
Exception Paths:	1. a) None
Includes:	None
Priority:	High
Frequency Of Use:	High
Business Rules:	Retrieved cases : 1. The cases retrieved must satisfy ranking criteria based on scoring method that implements a KNN algorithm.
Special Requirements:	None
Assumptions:	None
Process Owner:	Medical Expert
Notes and Issues:	None

4.1.5 Adaptation

The 3rd revision cycle of CBR course, triggers, rules, post and pre conditions requirements are indicated in table 5 below. This process will assist in repairing the cases therefore impacting on the system accuracy

Table 5: Adaptation use case

Use Case Id :	UC4		
Use Case Name:	Adaptation Dialog		

Version:	Version No	Created By	Date Created	Supervised By	Date Updated
	1.0	Mark K. Kiragu	Tuesday, September 1, 2015	Peter W. Wagacha	Tuesday, September 1, 2015
Actors:	Medical Experts & Diabetes Treatment &Management CBR System.				
Description:	The adaptation functionality provides a medical expert with an adaptation interface to provide a means of case revision and modification				
Precondition:	1.The case revision function must be available in the interface				
Trigger:	1. The User clicks on the set revision button to launch the case revision interface.				
Basic Course:	Procedure to adapt the values of a case using the case revision dialog. Launch the revision interface by clicking the set revision button. The System displays the case revision interface to containing the values of the previous cases to be revised. The medical expert keyed in and input the new values to be adapted. Upon Successful revision entry the system moves on to the next dialog of retention by clicking the set revision button End of case revision function use case. The 3rdR cycle is completed.				

Alternative Paths:	The medical expert can choose not to complete the 4 R cycle and exits the application by clicking on the exit button. The system exits end of use case.
Post Condition:	1. The revised details are stored in the application memory and retained in the 4th R of CBR cycle
Exception Paths:	a) If the expert enters invalid data the data in the field is reset to the default.
Includes:	None
Priority:	High
Frequency Of Use:	High
Business Rules:	Revision Dialog: 1. The case revision must provide a way of displaying and editing of the values to be modified.
Special Requirements:	None
Assumptions:	None
Process Owner:	Medical Expert
Notes and Issues:	None

4.1.6 Retention /saving of the case.

The 4th cycle of CBR process is illustrated in table 6 below. The process gives the conditions necessary to assist in system learning by saving of new cases.

Table 6: Retain use case

Use Case Id :	UC1				
Use Case Name:	Case retention Dialog				
Version:	Version No	Created By	Date Created	Supervised By	Date Updated
	1.0	Mark K. Kiragu	Tuesday, September 1, 2015	Peter W. Wagacha	Tuesday, September 1, 2015
Actors:	Medical Experts & Diabetes Treatment &g CBR System.				
Description:	The Retention functionality provides a medical expert with a dialog to assist in retaining the symptoms & tests results of a patient.				
Precondition:	1.The retain case function must be available in the interface				
Trigger:	1. The User launches the retain case dialog by clicking on the set revision button.				
Basic Course:	Procedure to retain of diabetes using the retain dialog. 1. The System displays the **revise case** interface. 2. The medical expert keys in the new values of attributes of diabetes using the widgets provided by the interface. ***3.*** Upon Successful entry of new value the expert then checks the save ***case with the new id*** check box. The case Id is incremented automatically ***4.*** The expert then click the apply button and click the next button to add the new case into the persistent memory. 5. End of retain case function use case. The **4^{th}R** cycle is completed.				
Alternative Paths:	1. The medical expert can choose not to complete the 4 R cycle and exits the application by clicking on the exit button. 2. The system exits end of use case.				

Post Condition:	1. The new case composed of a problem and solution description should be inserted into the database.
Exception Paths:	1. a) If the expert enters invalid data the data in the form is reset to the default.
Includes:	None
Priority:	High
Frequency Of Use:	High
Business Rules:	Retain Case: 1.The CBR application must have capture a case with a new ID>
Special Requirements:	None
Assumptions:	None
Process Owner:	Medical Expert
Notes and Issues:	None

CBR steps of execution from the start to end including conditional decisions is illustrated in figure 7.

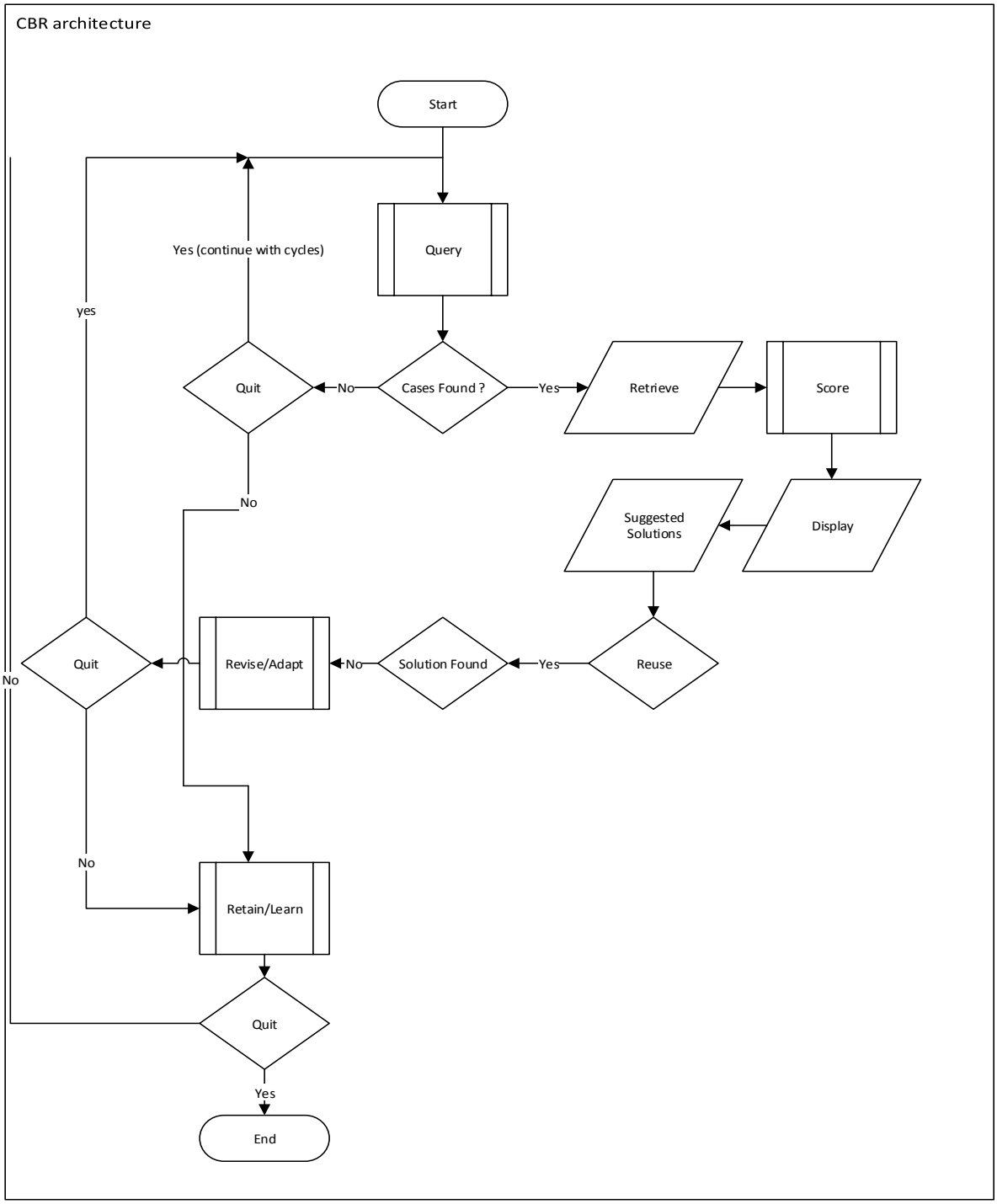

Figure 7: Diabetes management CBR flow chart.

Users & Modules interactions.

1) Medical Expert

Is the Diabetes specialist who was responsible for validating the learned cases the expert was the super user for the system.

2) User Interface

The Interface is the JAVA GUI that provided dialogs to execute the 4 R cycle.

3) Primary Functions

The Primary Functions includes the selection of the cases from the database based on the nearest neighbor algorithm list the cases and display them in a descending version starting with the most similar to the lease similar. The system implements the 4R methodology

4) Similarity Functions

The KNN algorithm was used to compare the new and target cases.

5) Hibernate

It is a Java framework used to map java objects to database objects by use of xml files.

MySQL Database

MySQL is an RDBMS database that was used for persistence storage of the diabetes cases.

4.2System Implementation

The CBR application has been implemented by use of a library which has algorithms for performing case similarity. The library is included in the CBR Application main class.

4.2.1Standalone CBR Application

A standalone CBR Application implemented in JAVA. The system implements an engine that has pattern matching capability. The system has four dialogs that provide a medical expert with an interface to enable a case based reasoning mechanism to help in diagnosis

& management of diabetes. See the figure 8 below for the in-depth details and model of the CBR framework architecture.

4.2.2 CBR Architecture diagram.

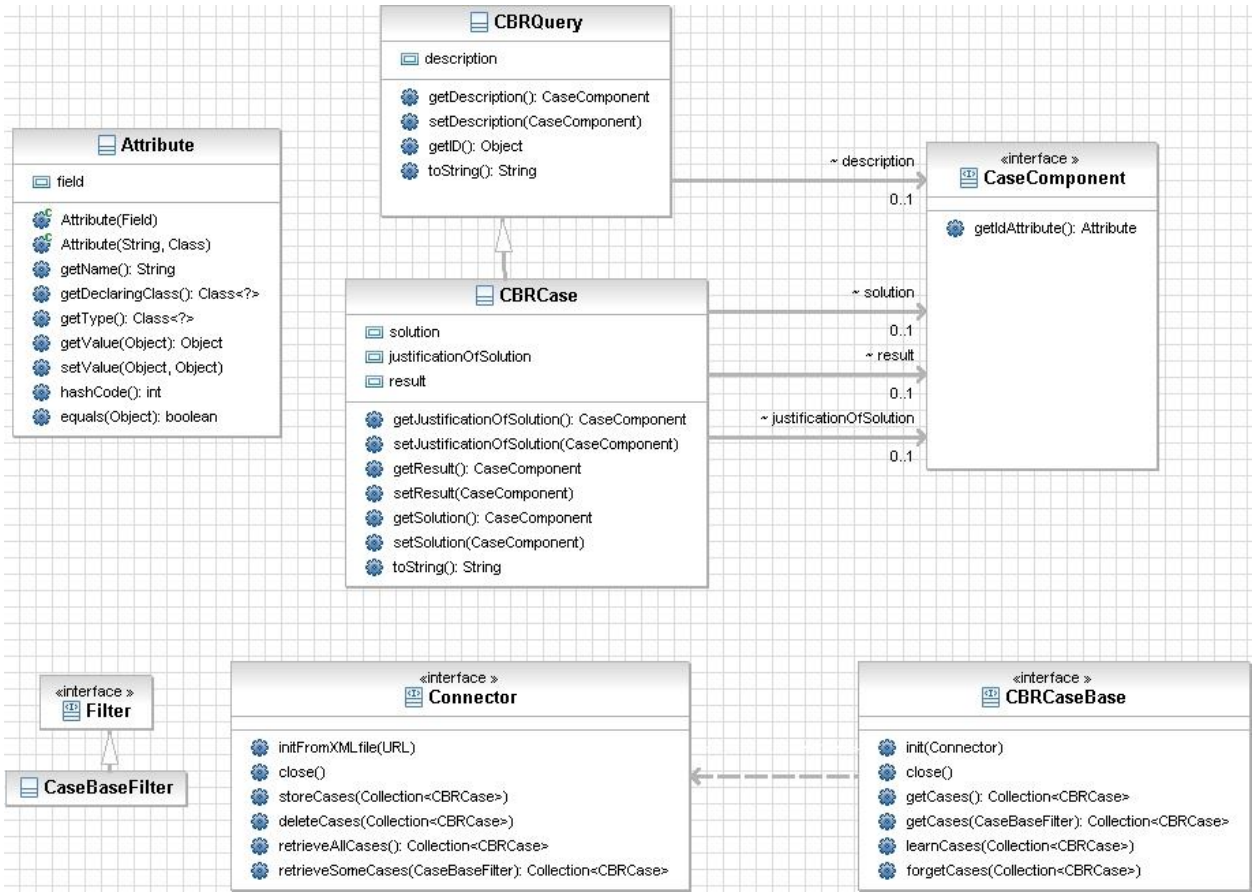

Figure 8: Jcolibri CBR architectural diagram (Source jCOLIBRI2 Case Based Reasoning Framework Documentation).

4.2.3Backend

This system has persistent storage for previous cases. The cases are stored in a MySQL database. Connection to the database has been done by use of hibernate database config xml file that helps to map the case description and case solution using JAVA beans.

The database supports different types of data including indexing mechanism for fast retrieval of cases.

4.2.4 Similarity Code

The strength of this system lies in its ability to do pattern matching. It compares the attributes of the current problem and retrieves the most similar previously experienced case. The system uses a nearest neighbor algorithm and Euclidean distance. Once the most similar cases are retrieved they are scored and listed In the order of importance.

4.2.5 Data Model

Figure4.4. Illustrate. A CBR diabetes treatment and management data model.

As illustrated in figure 9 below is the diabetes data model that was designed for persistence storage of the cases. The model consisted of both the problem and the solution.

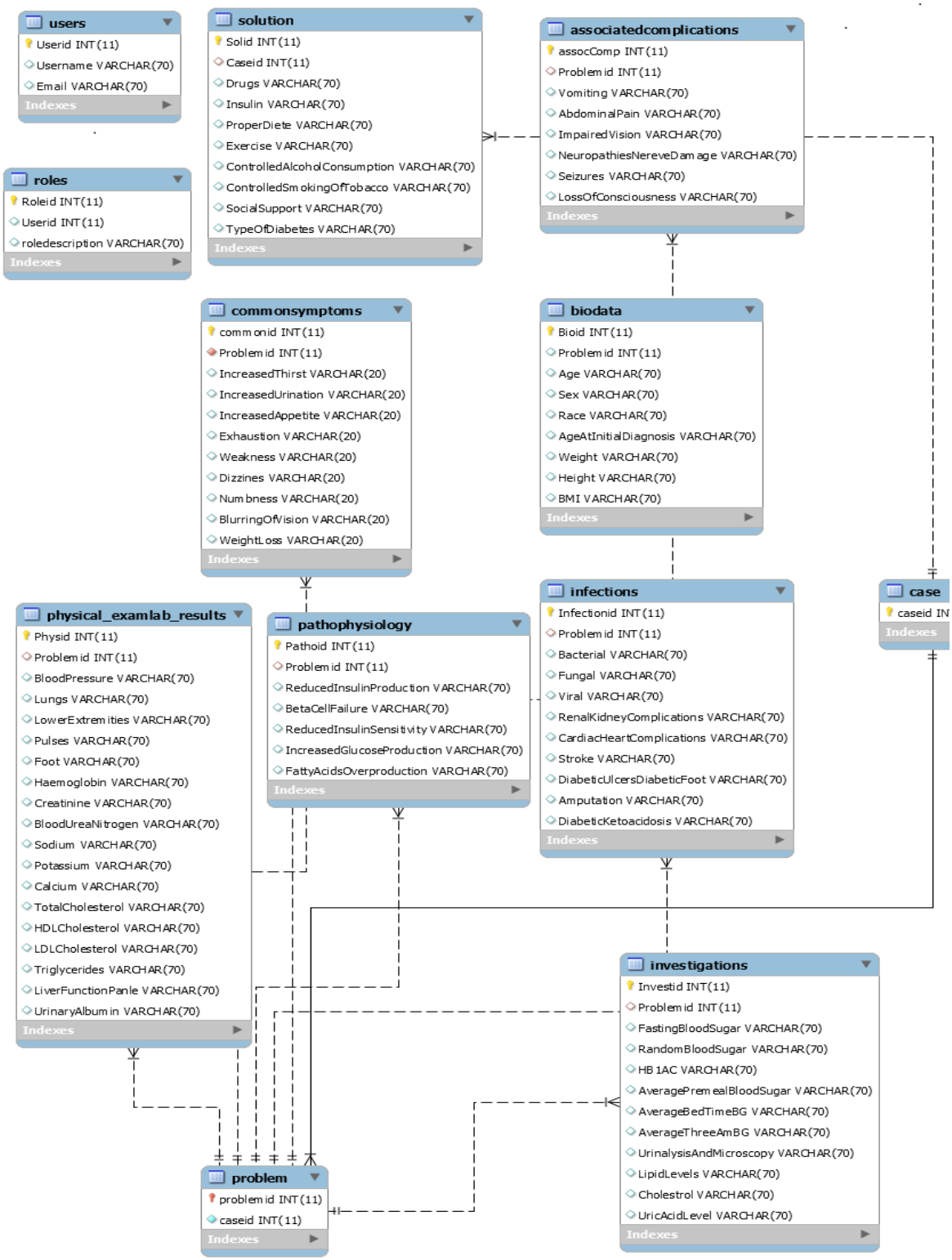

Figure 9:CBR for treatment and management of diabetes Data Model

CHAPTER 5

5.0 Results and Findings

5.1 System Training, Results and Accuracy

A prototype was developed using JCOLIBRI framework and trained with a total of 60 cases. 40 cases were type 1 and the remaining 20 cases type 2. A test data of 20 cases was used to measure the accuracy of the system. The key variables used in test were blood glucose, HBA1C (average blood glucose over 3 months), weight and height .The diagnosis predicted by the system was compared against the one obtained by the expert and the results were as follows. The system had a mean accuracy of 28 % before revision and after the first revision the system attained a mean accuracy of 70%. The accuracy was based on the difference between an expert judgment and a system judgment.

Real life cases used to train the system and subsequent results are indicated in table 7 below.

NB: The Data is real life captured from previous experiences.

Table 7: Trained diabetes cases

BLOOD SUGAR	AVERAGE	WEIGHT	HEIGHT	HBA1C(AVERAGE BLOOD SUGAR OVER 3 MONTHS)	SERVED BY	SIGN	DOSAGE
0	12.8				Mary		12/8
10.9	0			10.5	Mary		12/8
5.3	11.7				Joseph		12/8
8.8	11.2	25	136	14.1	Mary		12/8
0	0		144	11.1	Onesmus		18/12
11.5	0	28	145	12.4			16/10
15	0	53	159				32/18

BLOOD SUGAR	AVERAGE	WEIGHT	HEIGHT	HBA1C(AVERAGE BLOOD SUGAR OVER 3 MONTHS)	SERVED BY	SIGN	DOSAGE
18.1	0	58	159				35/18
15.8	0	58	159				35/25
13.3		61	159				35/25
19.1	0						30/25
14	22.9						30/25
0	0						30/25
0	0						25/20
0	0						35/30
16.6	0	71	164	>13			22/25
15.6	0	35	152	10.4			16/14
0	0						16/14
8.7	0	37	152	11.9			22/20
0	11.1						22/20
11.3	6.9						22/20

BLOOD SUGAR	AVERAGE	WEIGHT	HEIGHT	HBA1C(AVERAGE BLOOD SUGAR OVER 3 MONTHS)	SERVED BY	SIGN	DOSAGE
14.9	9.6	41	157	13.6			30/16
0							32/16
0							32/16
12		43	158	12.8			32/16
0							35/25
0							22/20
16.5	6.8	44	159				22/20
0							28/14
23.5	8.6	51	162	9.2			28/22
16.1		52	161	9.1			30/20
0							30/20
0							30/20
18.9	18.1	35	145				30/20
18.1	16.1	37	145	9.5			30/20

BLOOD SUGAR	AVERAGE	WEIGHT	HEIGHT	HBA1C(AVERAGE BLOOD SUGAR OVER 3 MONTHS)	SERVED BY	SIGN	DOSAGE
2.8	5.2	40	148	12.2			34/20
11.9	18.7	44	152				32/18
0							32/18
18.8		47	154	9.8			30/18
0							31/20
7.4							31/20
0							32/18
3.6		54	157	11.3			32/18
10.9		56	159	12.5			32/18
5.1		78	180	13.7			36/26
5.2		78	181	14			36/28
8.5		77	181	7.14			36/20
14.1		76	181				36/20
10		73	181				20/18

BLOOD SUGAR	AVERAGE	WEIGHT	HEIGHT	HBA1C(AVERAGE BLOOD SUGAR OVER 3 MONTHS)	SERVED BY	SIGN	DOSAGE
7.2							26/13
7.1							26/13
3.6		75	181	12.6			28/18
4.6		79	181	9.2			35/18
26.8	40/20	44	155				

Testing Data before Revision.

The Insulin dosage suggested for the 10 cases by the system differed from the expert dosage as shown below. The 3 params used are height, weight and blood glucose. The average accuracy of the system was 28 %. This indicated that the CBR is not very effective in the 1st and 2nd cycles. The test data and the associated system output before revision cycle is illustrated in table 8 below.

Table 8: Test Data before revision

Blood Sugar	Average Blood Sugar	Weight	Height	HBA1C	Expert Insulin DOSAGE	System Insulin Dosage with all 3 parameters	similarity with 3 params	Accuracy with 3 params in %	Accuracy with height only	Accuracy weight only
12.8	**12.8**				12/8	32/18	0.7	30%		
7.6		26	145	10.3	18/12	34/20	0.8	20%	16/10(1.0)	No Sol.(0.0)
8.0		56	159		35/15	34/20	0.8	20%	32/18(1.0)	32/18(1.0)0%
	15.2				25/16	32/18	0.7	30%		
12.1	17.3	63		7.14	30/25	26/13	0.646	40%		
24.6		70	163	>13	30/25	34/20	0.8	20%	No Sol.	No Sol. (0.0)
14.3	7.1	41	159	9.9	35/25	35/18	0.6	40%	32/18(1.0) 0	30/16(1.0)0%
4.5	18.1	35	145	12.1	30/20	34/20	0.8	20%	16/10 (1.0)	16/14(1.0)0%
					31/20	28/18	0.7	30%		

7.0		79	180	11.7	38/26			30%	No Sol (0.0)	35/18(1.0)
15.9	40/20	47	153					**28%**	**No Sol (0.0)**	**30/18 (1.0)**

NB: Where Blood Sugar was not recorded average blood sugar was used.

The Insulin dosage suggested for the 10 cases by the system was the same as the expert dosage as shown below. The average accuracy with 3 parameters (height, weight & blood sugar) was 70 % and with only blood sugar the average accuracy was 90 %. This indicated that CBR is very accurate after the 3rd (revision cycle) and that blood sugar is the key factor to consider in delivery of diabetes care. The test data and the associated system output after the revision cycle is illusrated in table 9 below.

Table 9: Test Data after revision

BLOOD SUGAR	**AVERAGE**	**WEIGHT**	**HEIGHT**	**HBA1C**	**Expert Insulin DOSAGE**	**System Insulin Dosage for all 3 params**	**similarity for 3 params**	**Accuracy in %**	**Accuracy with blood glucose only**	**Similarity for blood glucose(hb1ac)**	**Accuracy in %**
8.8	11.2	25	136	14.1	12/8	12/8	0.75	75%	12/8	1.0	100 %
11.5	11.5	28	145	12.4	16/10	16/10	0.75	75%	16/10	1.0	100 %
15	15	53	159	15	32/18	32/18	0.75	75%	32/18	1.0	100 %

18.1	18.1	58	159	18.1	35/18	35/18	0.5	50%	35/18	1.0	100 %
18.1	15.8	58	159	15.8	35/25	35/18	0.75	75%	35/25	1.0	100 %
13.3	13.3	61	159	13.3	35/25	35/25	0.75	75%	35/25	1.0	100 %
19.1	19.1	0	0	19.1	30/25	30/25	0.75	75%	30/25	1.0	100 %
14	22.9	0	0	18.4	30/25	30/25	0.75	75%	No sol.	0.0	0 %
16.6	16.6	71	164	16.6	22/25	22/25	0.75	75%	22/25	1.0	100 %
15.6	15.6	35	152	10.4	16/14	16/14	0.5	50%	16/14	1.0	100 %
								70%			90%

5.2 Formative Evaluation

A study was conducted with a sample size of 14 medical personnel. This survey was meant to find out whether the use of previous knowledge can be applied to resolve the current problems.

5.2.1 Figure 10 below shows the response in percentage of the reasoning based on experience, the use of previous experience to support health decisions in treatment and management of diabetes and fatalities reported based on expert's experience.

Figure 10: Reasoning Based on Experience. Response in percentage.

Table 10 below shows the response data in percentage for the graph above in figure 10.

Table 10: Experience Response

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly agree
Experienced Doctors Take less time to make clinical decisions	7.14	14.29	0	14.29	64.29
Experienced Doctors Make better Diagnosis & Treatment Plan	7.14	0	14.29	21.43	57.14
Patients managed by expert's record fewer fatalities.	0	14.29	7.14	35.71	42.86

When asked whether *the use of previous experience can be used to support health decisions* ***in treatment and management of diabetes78.58% (11/14.) agreed that Experienced Doctors Take less time to make clinical decisions 78.57 % (11/14) agreed that Experienced Doctors Make better Diagnosis & Treatment Plan and 78.57 % (11/14) agreed that Patients managed by expert's record fewer fatalities see table 10 above.***

5.2.2 Experience can be used to avert potential adverse risks in provision of health care to diabetic patients.

Table 11: Patient Fatalities Response

Question 1		
Experienced doctors record less patient fatalities		
Category	**Frequency**	**Percentage**
Strongly Disagree	1	7.14
Slightly Disagree	1	7.14
Neither Agree Nor Disagree	1	7.14
Slightly Agree	3	21.43
Strongly agree	8	57.14
Total	**14**	100

On patient fatalities 78.57 % (11/14) strongly agreed that less patient's fatalities are recorded after treatment and managed by experienced see table 11 above for the patient

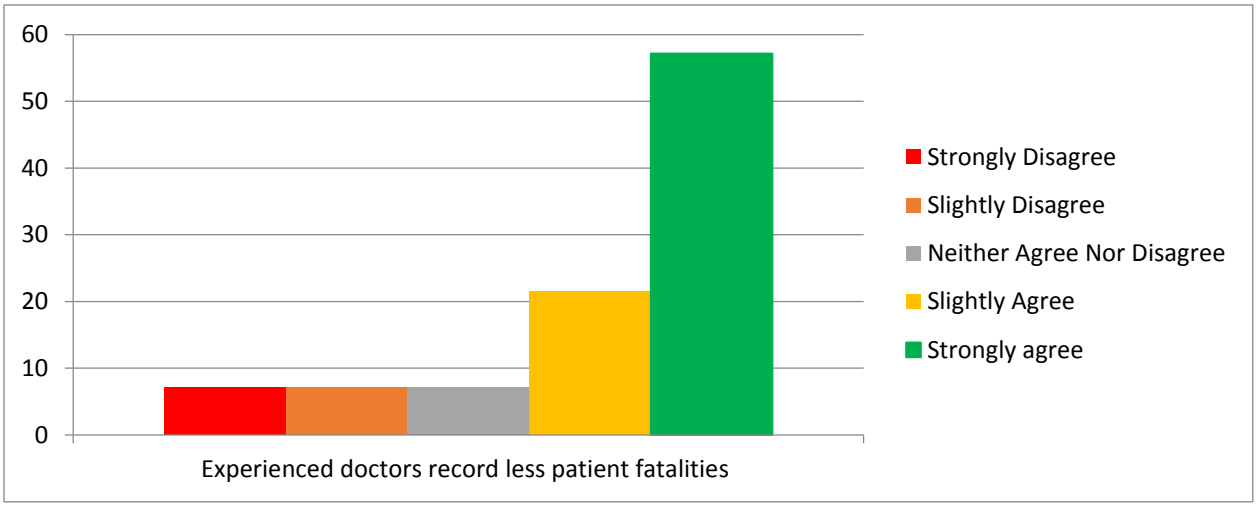

Figure 11:Patient Fatality Graph

fatalities response data in percentage and figure 11 above for the patient fatality graph.

5.2.3 We can help in planning management by referencing previous cases.

92.86% (13/14) of the respondents agreed that previous cases can be useful in planning management and 92.86 % (13/14) of the respondents agreed that previous cases can help in estimating management costs refer to figure 12 below for the time and cost estimate interventions report and its associated table 12 for the time and cost response data in percentage.

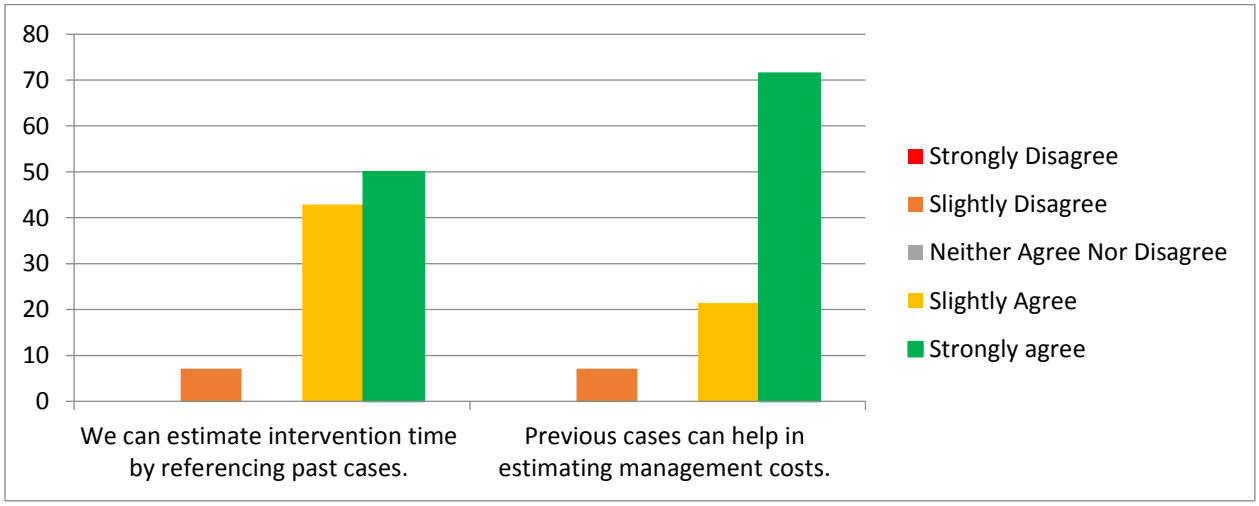

Figure 12: Intervention Based on Experience Graph

Table 12: Intervention Estimates Response

Question 1		
We can estimate intervention time by referencing past cases		
Category	**Frequency**	**Percentage**
Strongly Disagree	0	0
Slightly Disagree	1	7.14
Neither Agree Nor Disagree	0	0
Slightly Agree	6	42.86
Strongly agree	7	50
Total	**14**	100
Question 2		
Previous cases can help in estimating management costs		
Category	**Frequency**	**Percentage**

Strongly Disagree	0	0
Slightly Disagree	1	7.14
Neither Agree Nor Disagree	0	0
Slightly Agree	3	21.43
Strongly agree	10	71.43
Total	**14**	100

5.2.4 Past solutions can be used as answers for current problems.

74.99% (9/12) agreed that past solutions can be used as answers for current problems see figure 13 below for the past solutions response report and table 13 below for the past solutions response data

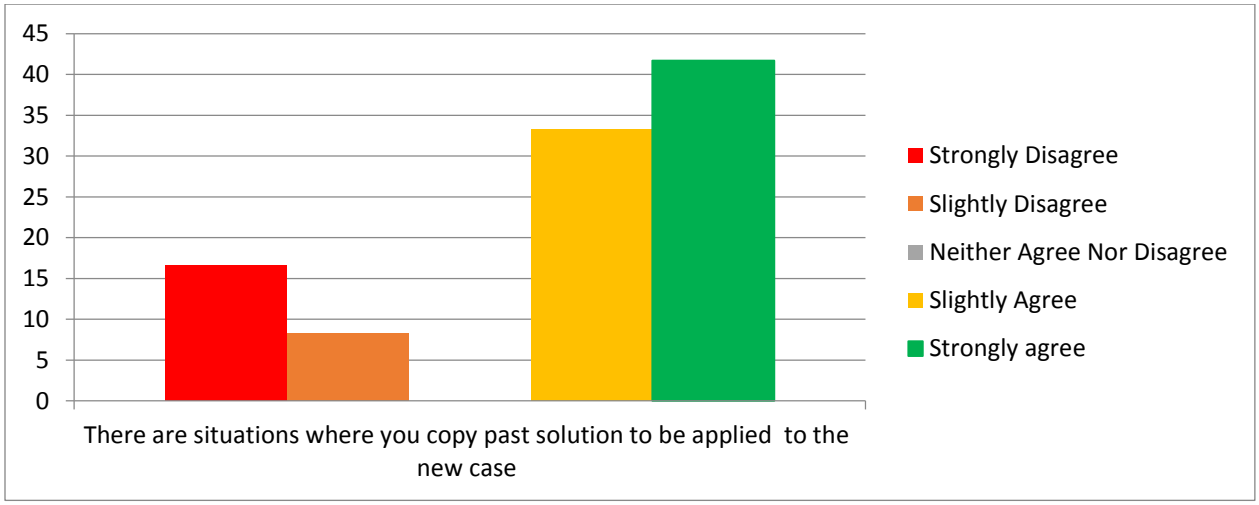

Figure 13: Past Solutions as Answers for New Problems

Table 13: Past Solutions Response

Question 1		
Past solutions can be used as answers for current problems		
Category	**Frequency**	**Percentage**
Strongly Disagree	2	16.67
Slightly Disagree	1	8.33
Neither Agree Nor Disagree	0	0
Slightly Agree	4	33.33
Strongly agree	5	41.67
Total	**12**	**100**

5.2.5 Prevalence of Diabetes in Kenya.

When asked whether the diabetes cases are on the rise 92.85 % (13/14) were in agreement that the prevalence of diabetes is on the rise. See figure 14 for the prevalence response graph and table 14 below for the prevalence data table

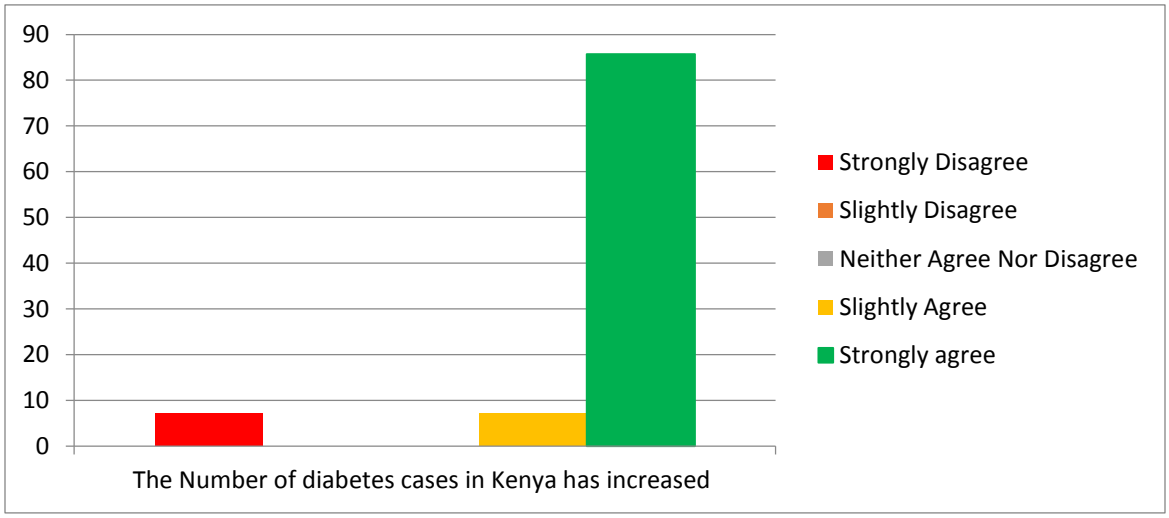

Figure 14: Diabetes Cases in Kenya

Table 14: Prevalence Response

Question 1			
Prevalence of diabetes in Kenya			
Category	**Frequency**	**Percentage**	
Strongly Disagree	1	7.14	
Slightly Disagree	0	0	
Neither Agree Nor Disagree	0	0	
Slightly Agree	1	7.14	
Strongly agree	12	85.71	
Total	**14**	**100**	

5.2.6 In most cases similar diagnosis has similar treatment & management options.

When experts were interviewed to find out whether similar cases have similar treatment and management options 85.72 % (12/14) agreed and when asked whether a diabetes diagnosis, management & treatment can be reused 71.43 % (10/14) agreed .This strongly supports the CBR concept of dynamic memory and case reuse for solution provision to a new case refer to figure 15 for the interdependence between conditions and symptoms graph and table 15 below for the interdependence between conditions and symptoms data

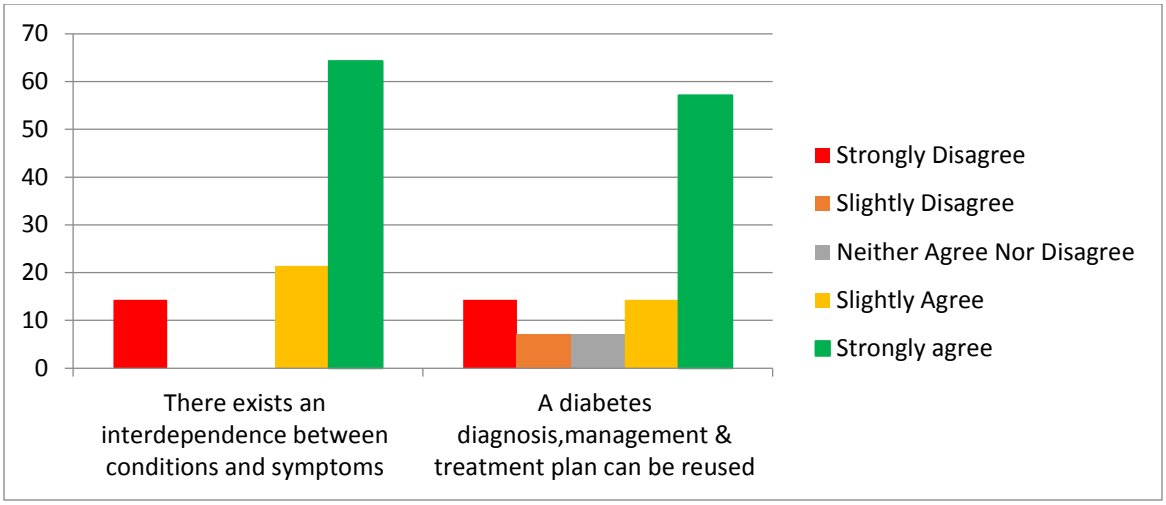

Figure 15: Interdependence between Conditions and Symptoms

Table 15: Interdependence Response

Question 1		
There exists an interdependence between conditions and symptoms		
Category	**Frequency**	**Percentage**
Strongly Disagree	2	14.29
Slightly Disagree	0	0
Neither Agree Nor Disagree	0	0
Slightly Agree	3	21.43
Strongly agree	9	64.29
Total	**14**	**100**

Question 2		
A diabetes diagnosis, management & treatment plan can be reused		
Category	**Frequency**	**Percentage**
Strongly Disagree	2	14.29
Slightly Disagree	1	7.14
Neither Agree Nor Disagree	1	7.14
Slightly Agree	2	14.29
Strongly agree	8	57.14
Total	**14**	**100**

5.2.7 A computer software can be used as a tool to support clinical decisions.

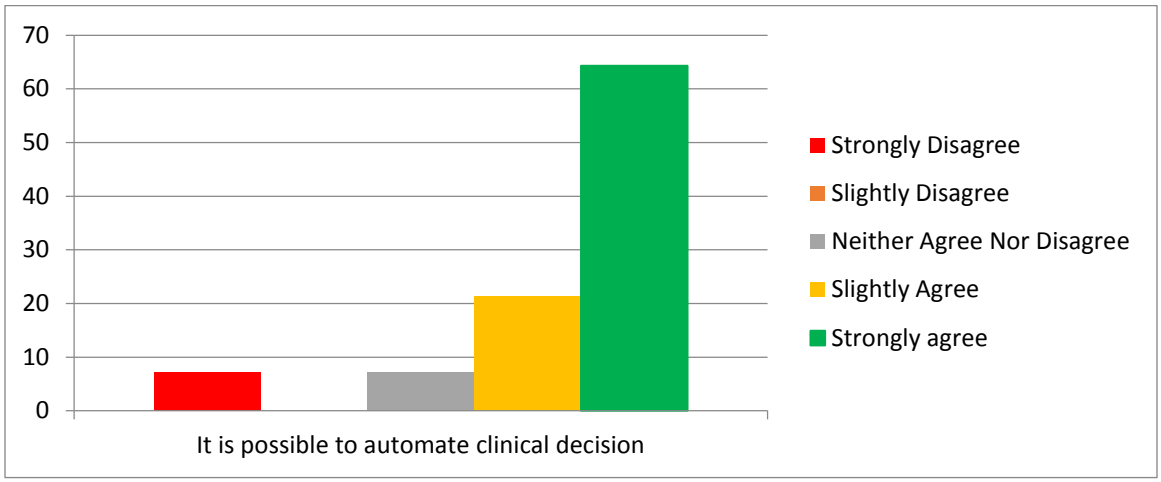

Figure 16: Clinical Decision Automation

Table 16: Clinical Automation Response

Question 1		
It is possible to automate clinical decision		
Category	**Frequency**	**Percentage**
Strongly Disagree	1	7.14
Slightly Disagree	0	0
Neither Agree Nor Disagree	1	7.14
Slightly Agree	3	21.43

Strongly agree	9	64.29
Total	**14**	**100**

85.72 %(12/14) agreed that computer software can be used as a tool to support clinical decisions. See figure 16 above for the automation response graph in percentage and table 16 above for the automation response data.

5.2.8 Advanced conditions are better treated by experienced medical experts.

61.54 % (8/13) agree that advanced conditions are better treated by experienced medical experts see figure 17 below for the advanced conditions response graph in percentage and table 17 below for advanced conditions response data.

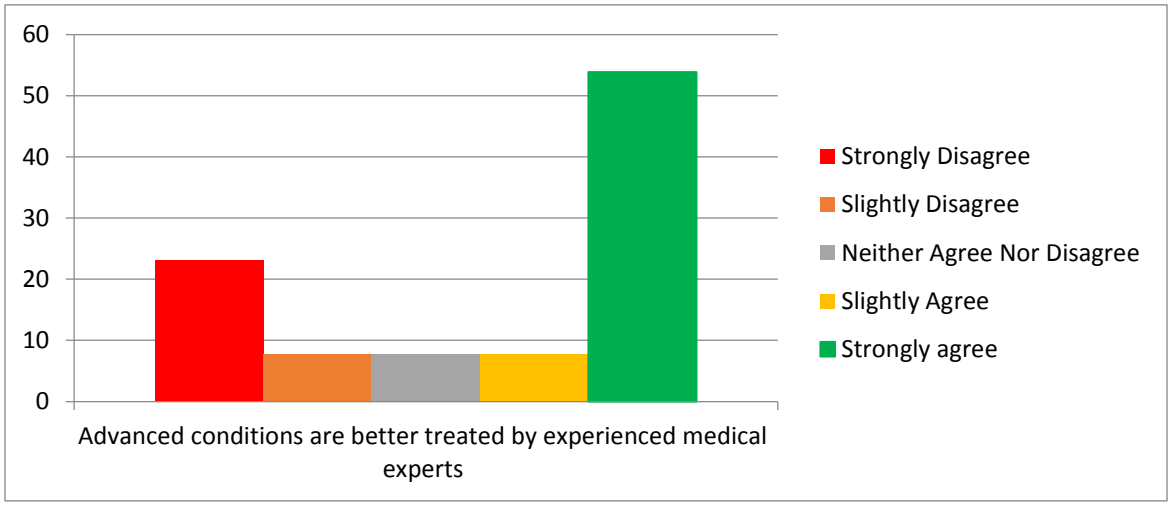

Figure 17: Advanced Conditions are Better Treated by Experienced Medical Experts

Table 17: Advanced Conditions Treatment Response

Question 1		
Advanced conditions are better treated by experienced medical experts.		
Category	**Frequency**	**Percentage**
Strongly Disagree	3	23.08
Slightly Disagree	1	7.69
Neither Agree Nor Disagree	1	7.69
Slightly Agree	1	7.69

Strongly agree	7	53.85
Total	**13**	**100**

The following section summarizes the feedback from the experts.

5.3 Summative Evaluation

- After development the tool was evaluated by 10 experts.
- The following was undertaken by the experts
- Training of the tool with previous cases of diabetes. The system aided in recording the cases and saving the case in a persistent memory.
- Used the trained system to diagnose and make clinical judgments of new cases based on the similarity of previous cases.
- Administered an evaluation questionnaire to test the outcome and impact of the tool.
- The questionnaire tested on ease of use, usefulness of the tool, attitude to use the system, areas to be improved, part of the software to be added or removed, the user experience of the interface and the functionality of the system.

5.3.1 Response on Easy of use

60% of the experts agreed that the software was easy to use and 70 % agreed that it was interesting to use refer to figure 18 below for ease of use graph report.

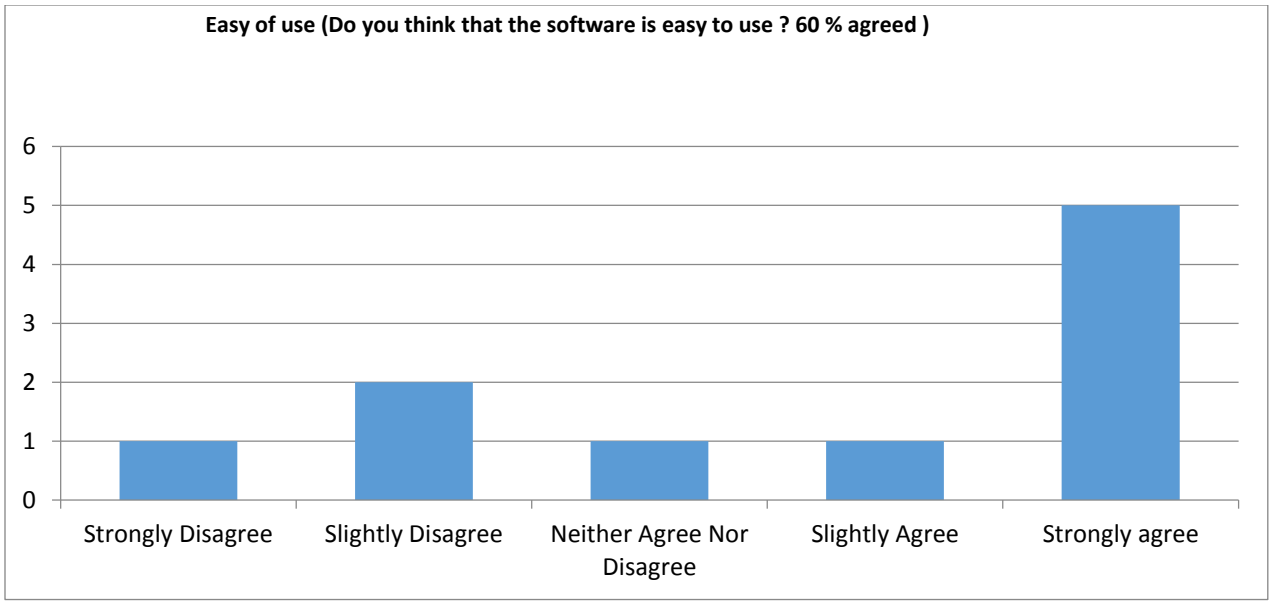

Figure 18: Easy of Use

ii. Do you think that the software is interesting to use?

Figure 19 below shows the interest response as a continuation of ease of use evaluation.70 % agreed that the software was interesting to use.

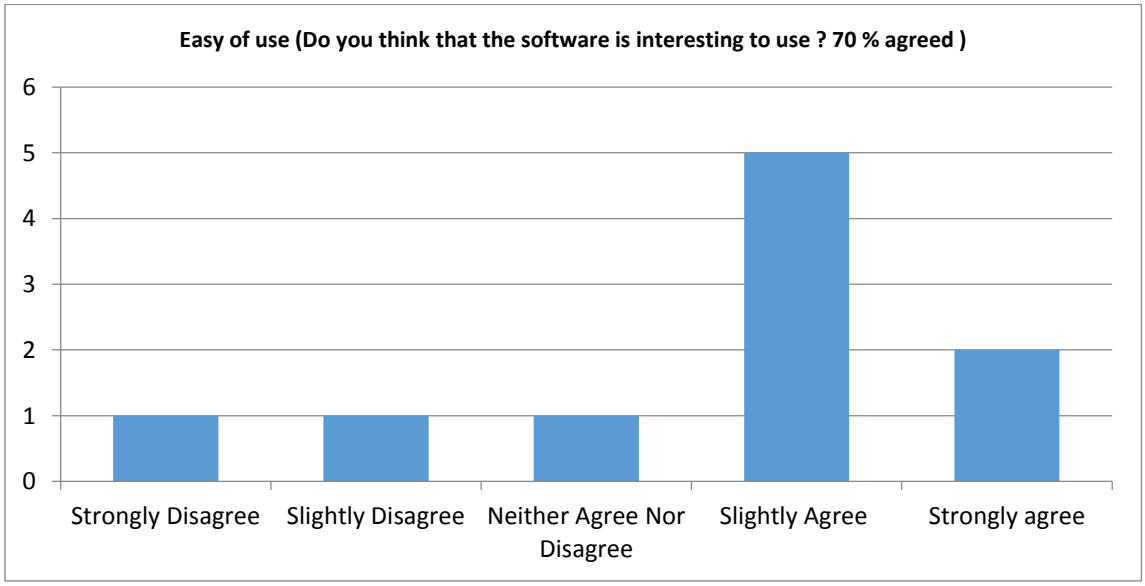

Figure 19: Easy of Use (Interest Response)

Figure 20 below shows the interaction level response graph. Only 20% agreed that they use the system everytime.

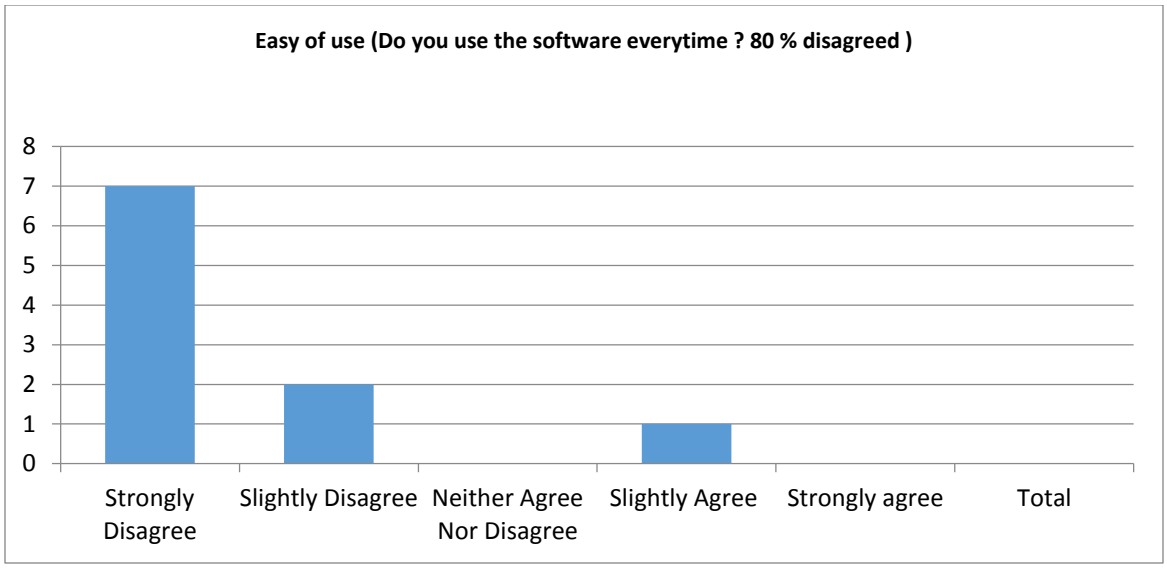

Figure 20: Easy of Use (Interaction Response)

5.3.2 Satisfaction

40 % agreed that they are satisfied with the tool and another 50 % agreed it was fun to use the software. Figure 21 below shows the satisfaction response. 90 % agreed that they were satisfied with the software

Satisfaction chart

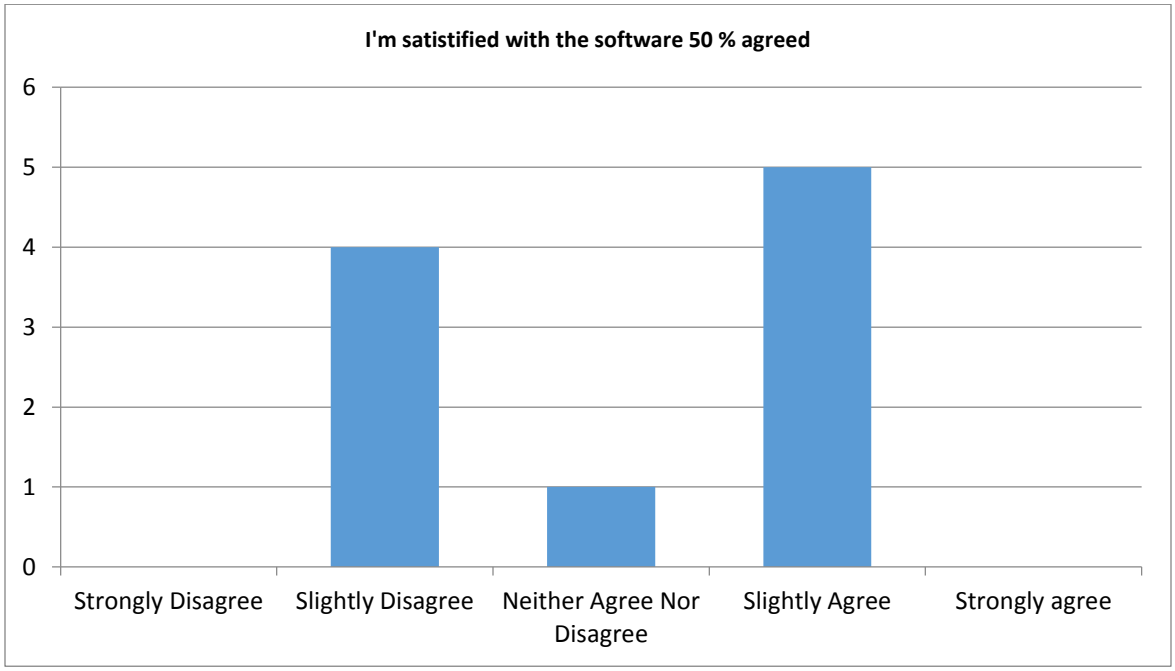

Figure 21: Satisfaction Response

60 % agreed that it was fun to use the software see figure 22 below for fun response data

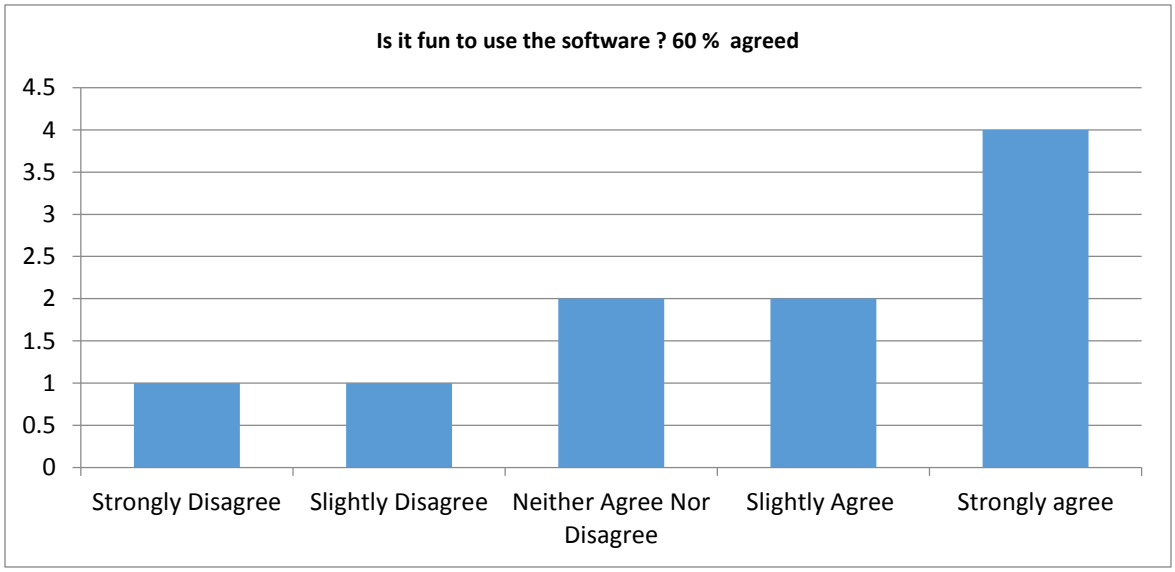

Figure 22: Satisfaction Fun Responses

5.3.3 Interface

50 % of the respondents accepted that the user interface is attractive see figure 23 below for response chart.

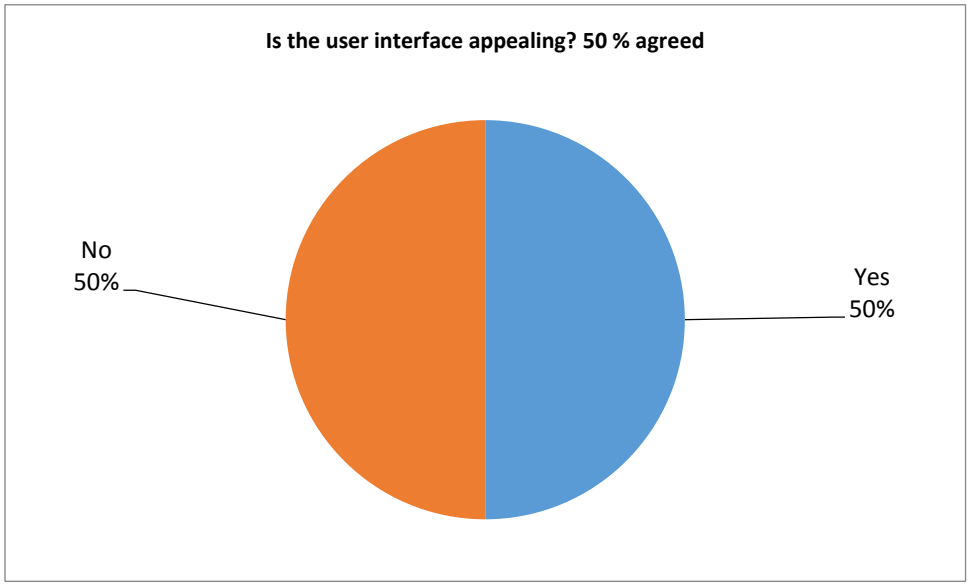

Figure 23: Interface

5.3.4 Interesting

60 % of the respondents agreed that they always feel like to use the system refer to figure 24 for the response chart

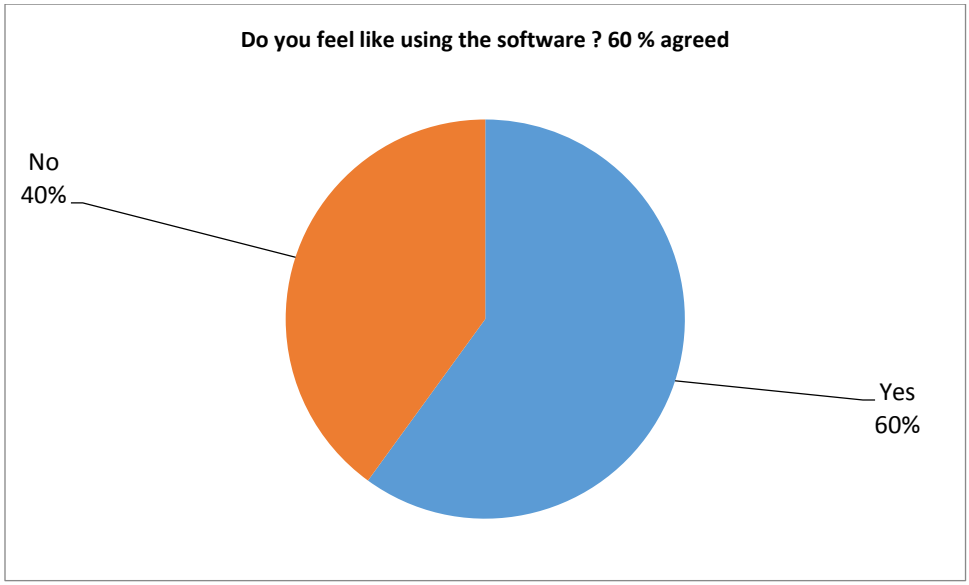

Figure 24: Interest Graph

5.3.5 Features to be added

1) The users recommended a mobile version and a web based version to enhance accessibility to the system.
2) Management of complications of the diabetes and diabetic related cases
3) Integration to the existing hospital system to book patients after seeing them.

5.3.6 Most Useful Features of The System

From the participant's response case resolution and management, signs and symptoms were the most useful features of the system.

Do you think this software can be used to improve on medical diabetes interventions? 80 % of the respondents as illustrated in figure 25 agreed that the tool can help in medical interventitions.

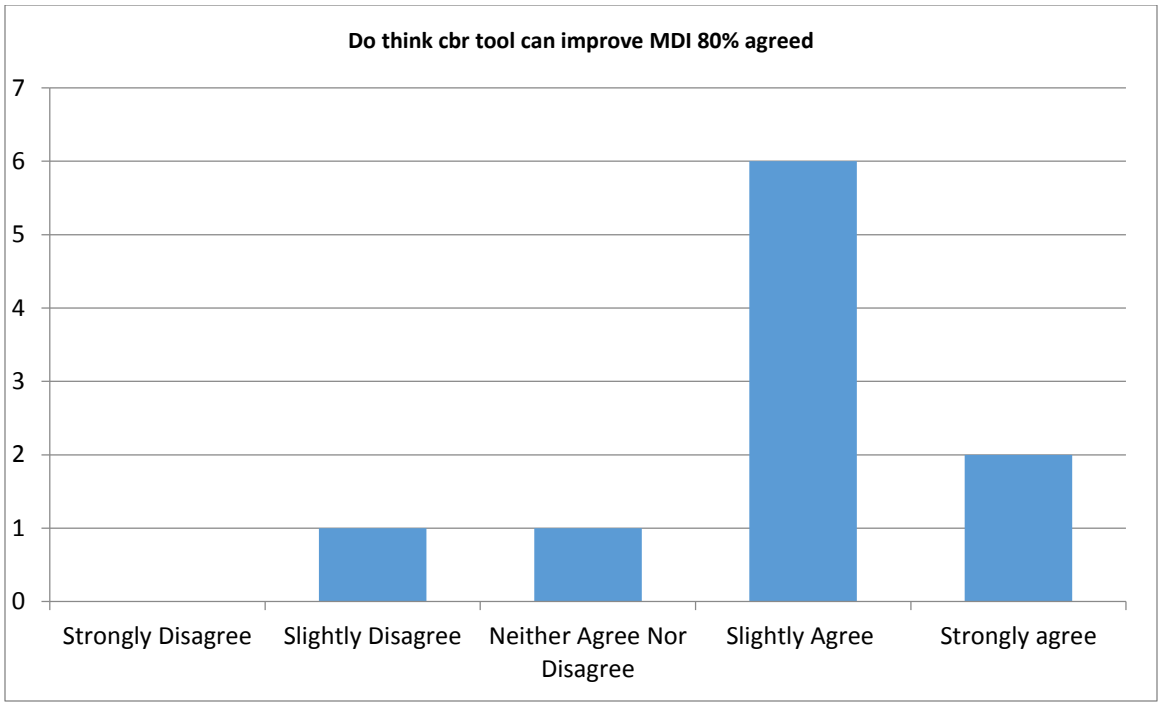

Figure 25: CBR intervention responses

Can the system be used to prevent relevant risks? 90 % agreed that the software can be used to predict risks as shown below in figure 26.

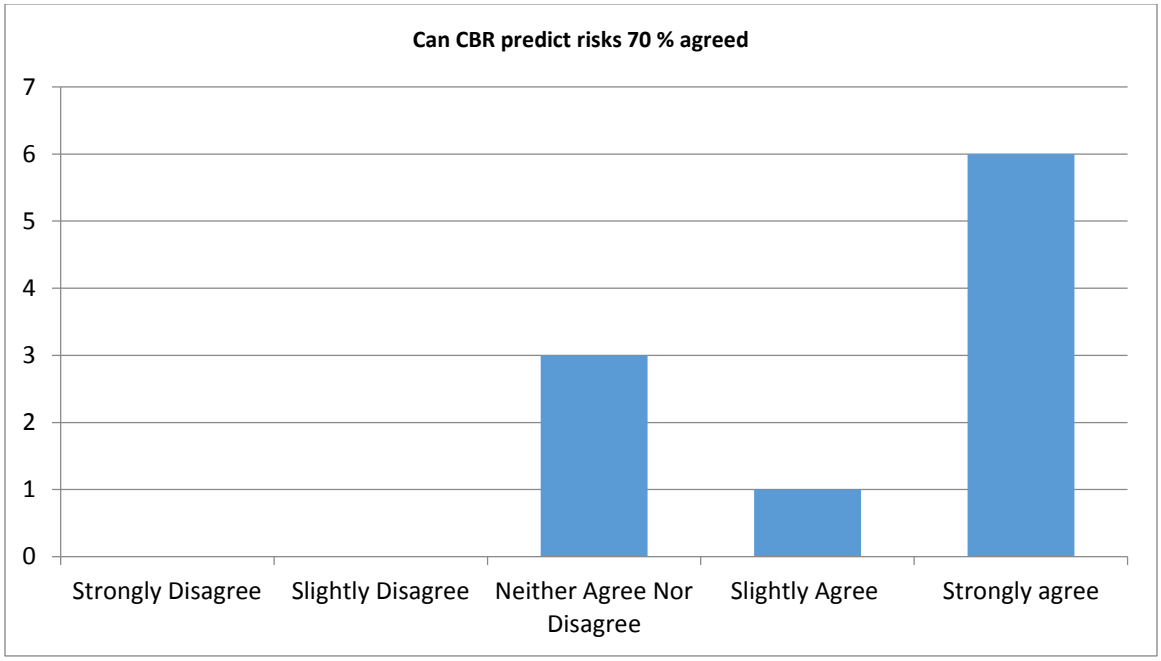

Figure 26: CBR Risk Response

Can CBR be used to justify medical decsions? 80 % agreed that CBR can be used to justify medical conditions as shown below in figure 27.

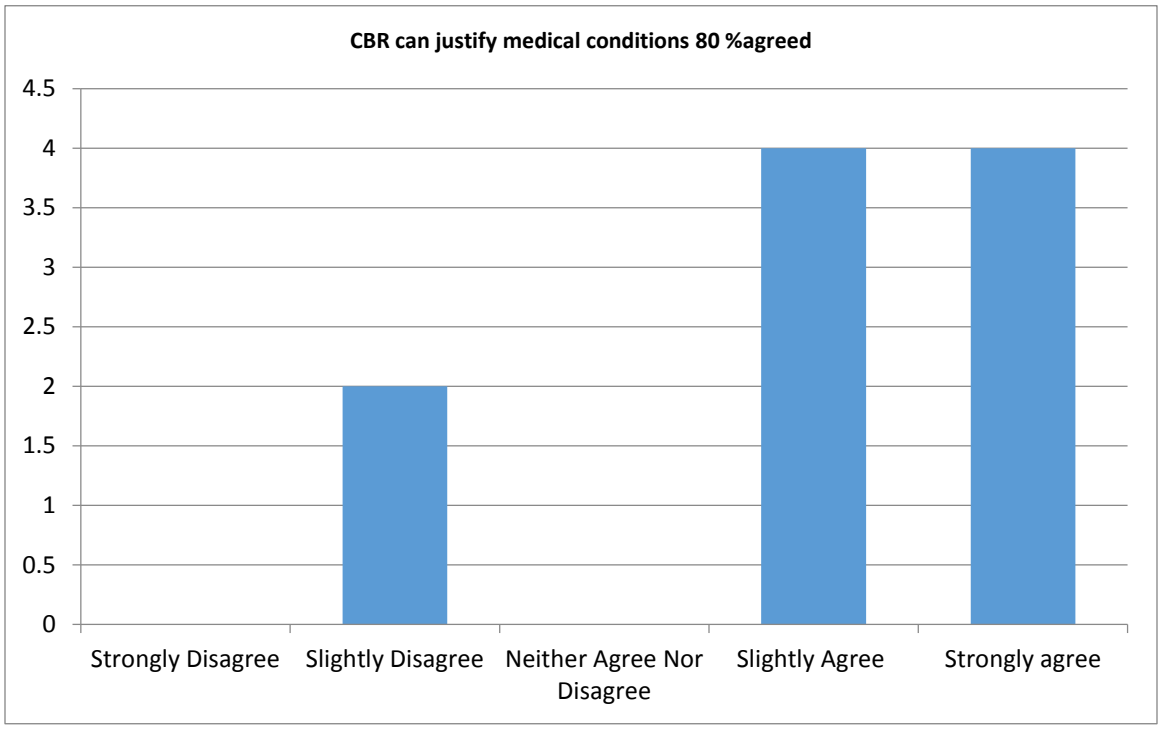

Figure 27: CBR Justification Graph

5.3.7 Usefulness of the Tool

70 % agreed that they become more effective when using the software, 20% agreed that they were more productive when using the software and that this tool can simplify clinical decisions see response graph below in figure 28 below

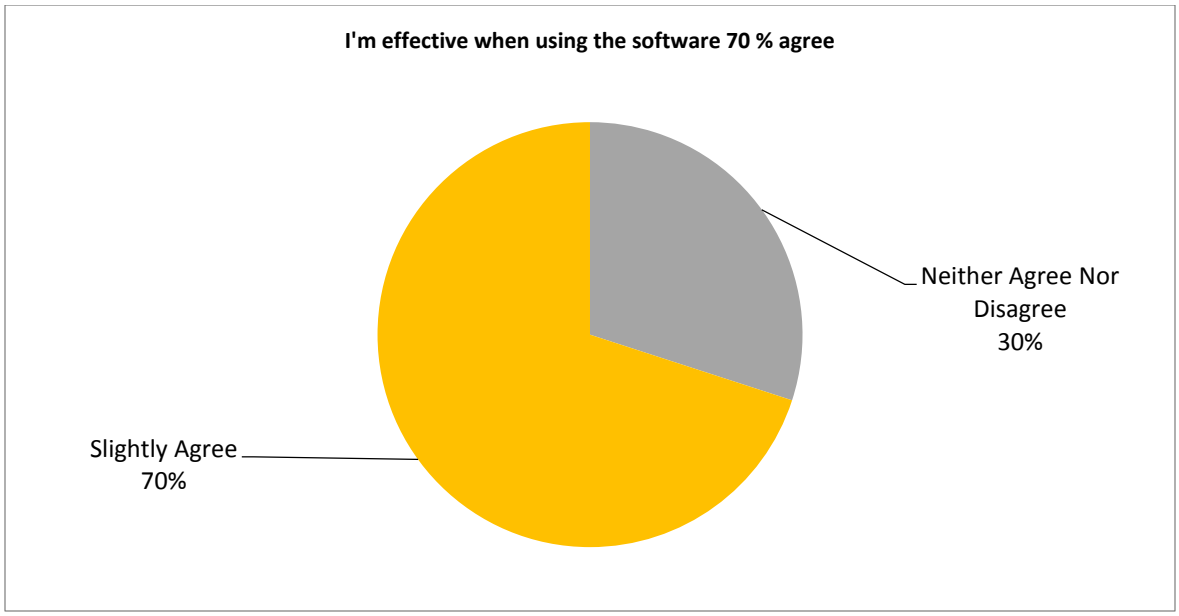

Figure 28: Effectiveness Response

I am more productive when using the software? 80 % agreed that they are more productive when using the software see figure 29 for the response data.

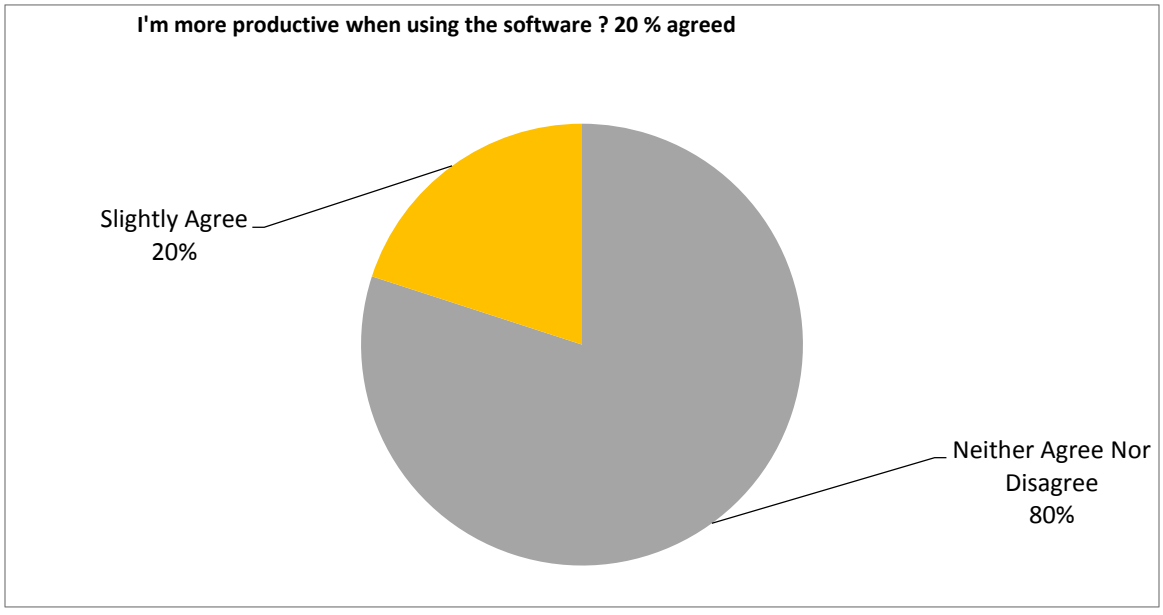

Figure 29: productivate Response

I use the software everytime?

80 % disagreed that they use the software every time see figure 30 below

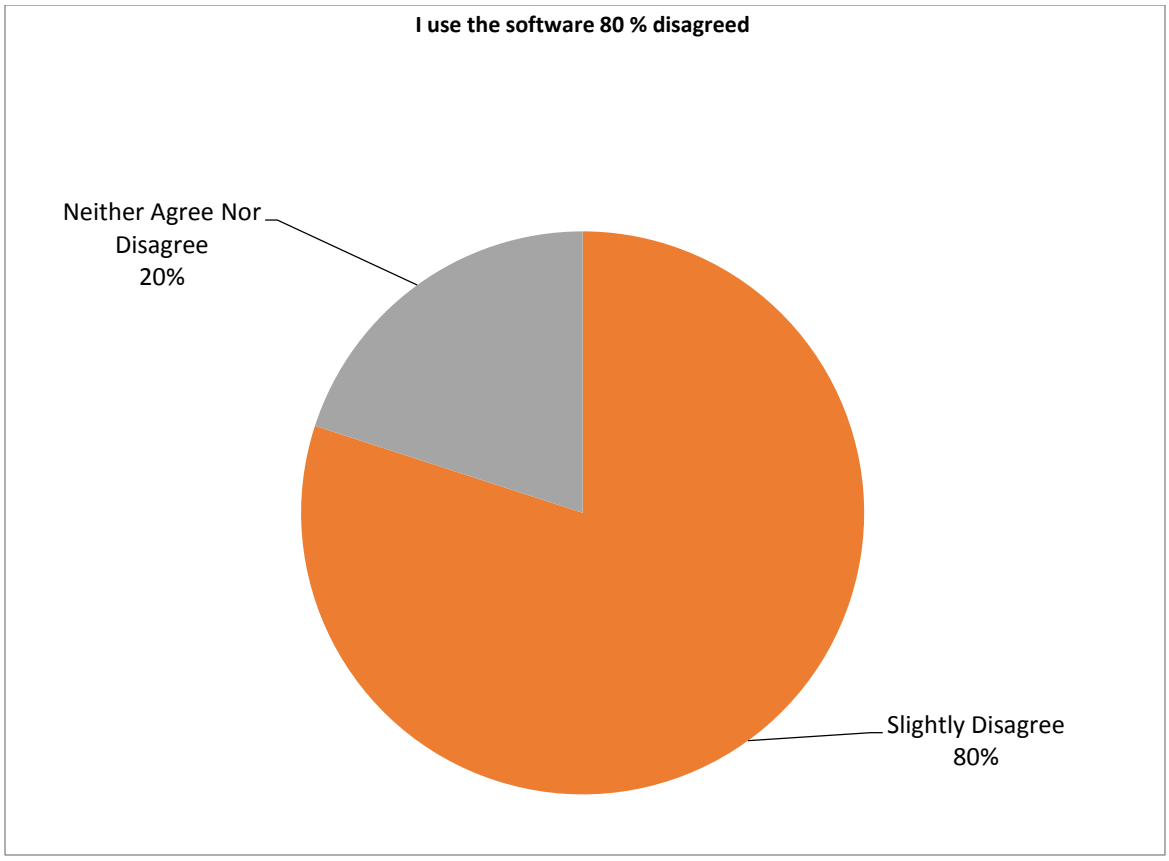

Figure 30: Interaction response

From the above response it is clear that the CBR tool would simplify clinical judgments, help in planning and management of the interventions, predict management cost, and list possible diagnosis risks provide justification and knowledge regarding the new cases encountered.

CHAPTER 6

6.0 Conclusion and Future Work

A CBR Application was developed for treatment and management of diabetes. The application was meant to demonstrate reasoning by use of previously experienced past cases. The system employed case based methodology of reasoning which involves the 4 R process. The success of the system relied on use of a similarity matching between the new case and the target cases. A case in this context implies a problem solution pair. The problem consists of diabetes problem description (symptoms) and its solution. The problem structure was defined by a medical expert. The system was deployed and tested with real life cases and then updated by a medical expert. The CBR concept implemented had an accuracy of 75 % with 3 parameters (Blood glucose, height& weight) and an accuracy of 90% with 1 parameter (blood glucose) after the revision cycle (3rd cycle of CBR) which proves that the competence of the system increases as the number of case increase. From the accuracy of 90 % we can conclude that the key factor to consider when treating diabetes is blood glucose. The accuracy of the system can further be improved by combining different pattern matching algorithms such as (Euclidean and Hamming distances together) and building a bigger case base. It was noted that the CBR accuracy was highest after the revision (3^{rd} cycle) and as the number of cases increased. This study involved work that led to

1) An application that uses a library that is used for treatment and management of diabetes the application supports retrieval, reuse, revision and retention of cases and implements learning in order to solve new problem based on previous solution for similar problems.
2) A memory in form of text or database for storing diabetic cases (Problem – solution pair)
3) An experience processing application that is used for explanation, justification and risk analysis in diabetes treatment, diagnosis & management interventions

6.1 Limitations

1) It was a challenge to initially train the system as the application required to gather real life cases to be trained.

2) The retention of the cases is a manual process. It requires the intervention of a medical expert.

6.2 Future Work.

1. Improve the competency of CBR by building a bigger or larger case base.
2. Use the same concept for the treatment of other medical conditions.
3. To improve the accuracy of CBR to greater than 95 %
4. Integrate CBR to existing medical systems.
5. Develop a methodology for self learning case based reasoning systems where cases are not available

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Appendices

Appendix 1 - Sample source code

```
/**
 * Bean that stores the description of the case.
 * @author Mark Kiragu
 * @version 1.0
 */
public class Diabetes Description implements jcolibri.cbrcore.CaseComponent {
        String    CaseId;
        String    IncreasedThirst;
String    Increased Urination;
        Stri


// Return the string version of the class.

        public String to String()
        {

                return
"("+CaseId+";"+IncreasedThirst+";"+IncreasedUrination+";"+IncreaesedAppetite
**********
**********

"+NeuropathiesNerveDamage+";"+SeizuresHeight+";"+BMI+")"
        //ALL THE SET METHODS of the diabetes bean attributes.
        //public          void          setCaseId(Integer      CaseId)        {
        this.CaseId     =       CaseId;       }
        //public   void   setCaseId(String   CaseId)   {   this.CaseId =   CaseId;}
this.ControlledSmokingOfTobacco    =   ControlledSmokingOfTobacco ;}
        public   void   setSocialSupport (String   SocialSupport)    {    this.SocialSupport
        = SocialSupport ;}
        public   void   setTypeOfDiabetes(String      TypeOfDiabetes)       {
this.TypeOfDiabetes   = TypeOfDiabetes;} */

//solution class

/**
 * Diabetes Solution
 * @author Mark Kiragu.
  * 25/08/2015
 */
package cbr;
```

```
import jcolibri.cbrcore.Attribute;

/**
 * Bean that stores the solution of the case (trip)
 * @author Mark k. Kiragu
 * @version 1.0
 */
public class DiabetesSolution   implements jcolibri.cbrcore.CaseComponent {

        String id;

        String    Drugs;
        String    Insulin;
        String    ProperDiet;
        public String toString()
        {

                return
"("+Drugs+";"+Insulin+";"+ProperDiet+";"+Exercise+";"+ControlledAlcoholConsum
ption+";"+ControlledSmokingOfTobacco+";"+SocialSupport+";"+TypeOfDiabetes+")"
;
        }
                }
        /**
         * @param id The id to set.
         */
        public void setId(String id) {
                this.id = id;
        }
}


Class CBRApplication
/**
 * This is the main class for the CBR application it invokes all other dialogs methioned in
the  the 4R methodology
 * @author Mark K. Kiragu
 * 25/08/2015
 */

package cbr;

import jcolibri.cbraplications.StandardCBRApplication;
import jcolibri.cbrcore.CBRCase;

import java.awt.Dimension;
```

```
import java.util.ArrayList;
import java.util.Collection;

publicclass CBR Application implements StandardCBRApplication {

        privatestatic CBRApplication _instance = null;
        publicstatic CBRApplication getInstance()
        {
                if(_instance == null)
                _instance = new CBRApplication();
                return_instance;
        }

        private CBRApplication()
        {
        }

        /** Connector object */
```

Appendix 2 Installation Instruction

JDK Installation

1) Download jdk1.8 from http://www.oracle.com/technetwork/java/javase/downloads/index-jsp-138363.html
2) Install the JDK using the installation documentation provided on the link in step one.
3) Set the environment variables by right clicking on the computer icon then going to properties. Click on the advanced tab setting and click on the advanced button.
4) Click on the environment variables button and set the java home as shown below in figure 31 A2.

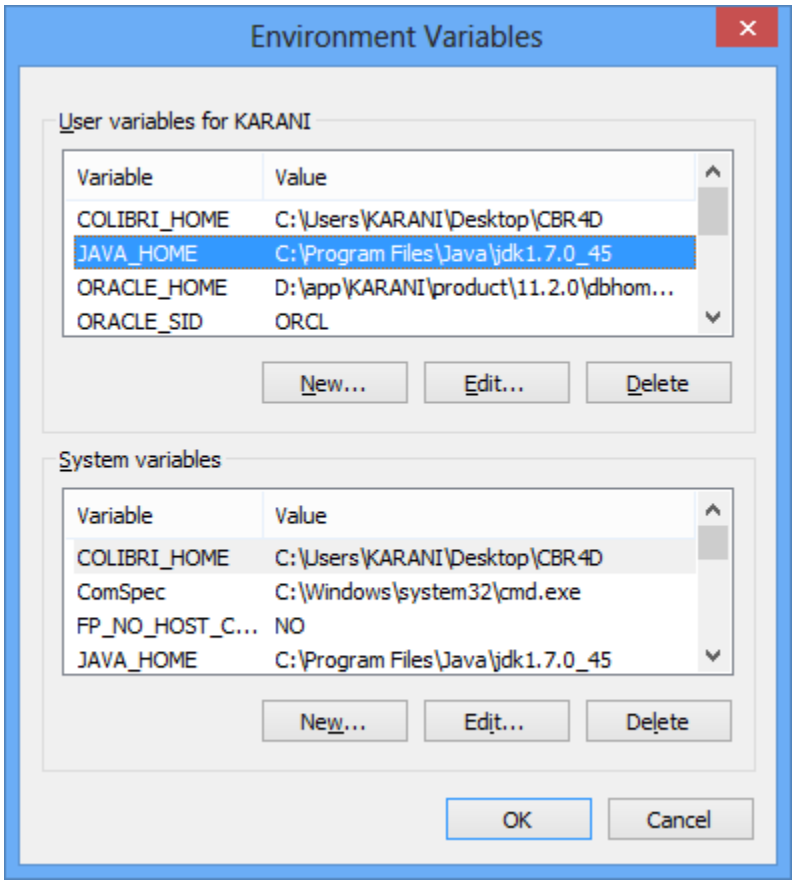

Figure 31 A2:Environment Variables for JAVA_HOME

MySQL database installation instructions.

1) Download the wampserver installation setup.
2) Copy the download on the desktop.
3) Launch the installation by clicking on the setup button as illustrated below in figure 32 A2
4) Choose the directory where to store the setup files.

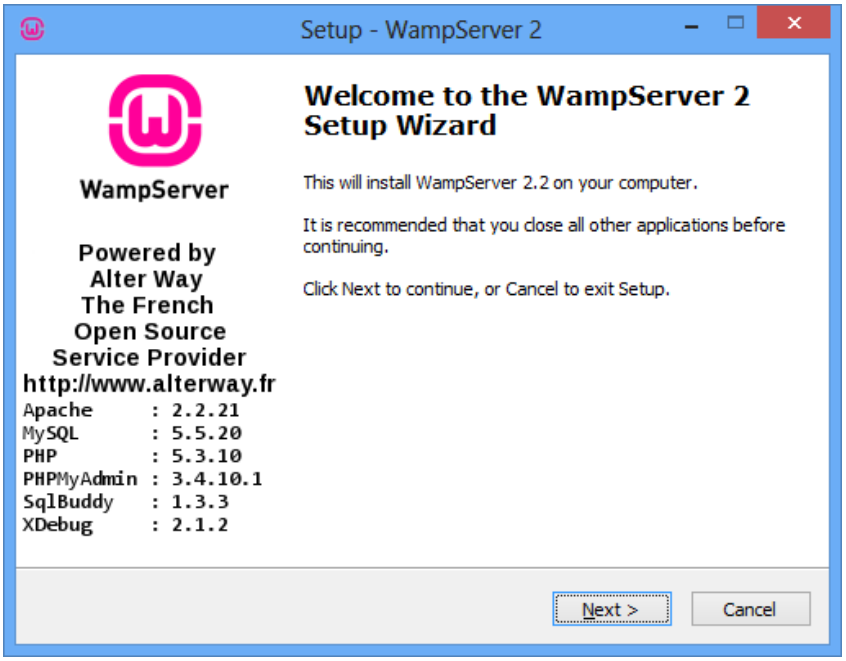

Figure 32 A2:WampServer2 Setup Wizard

Start all the services and ensure the database is running as shown below in figure 33 A2

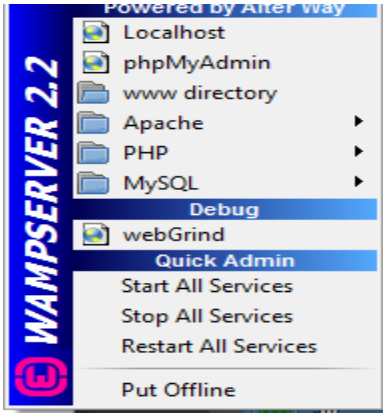

Figure 33 A2:WampServer 2.2 Admin Menu

Setting the enviroment for the JCOLibri path.

Set the JCOLIBRI Home path from the enviromnent variables.This is the folder that contains your CBR application as indicated below in figure 34 A2

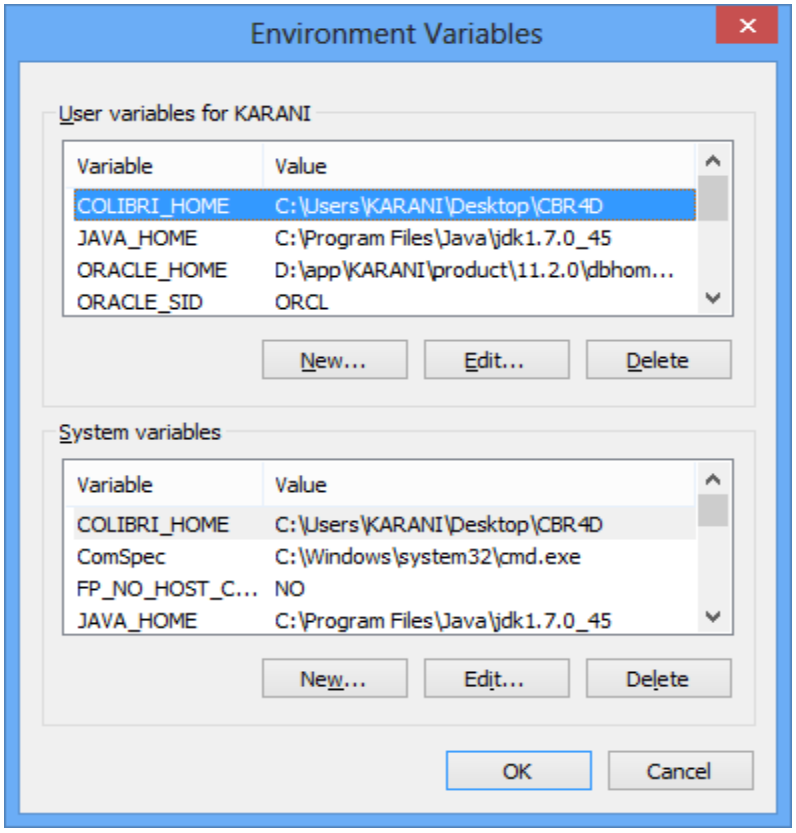

Figure 34 A2: Environment Variable COLIBRI _HOME Wizard

Creating an executable batch file .

Create a dot batch file containing the following instructions to launch the CBR application as shown in figure 35 A2.

java -Xms256m -Xmx1024m -cp lib/jcolibri2.jar;CBR5D.jar jcolibri.util.Launcher cbr.CBRApplication.

Figure 35 A2:CBRApplication for Diabetes

Appendix 3. User manual for the CBR tool.

This screen provided the controls that were used for the aid of the retrieval of previous similar cases. It provided the interaction by the use of controls displayed.

Configure query dialog steps:

1) Launch the application by clicking on the **CBR**application icon on the desktop.
2) The system presented the configure query interface illustrated below in figure 36 A3
3) The interface is grouped into the following sectiorns common symptoms, associated with complications, frequent infections, investigations, pathophysiology and biodata.
4) Enter the values for the current diabetic patient by selecting the dropdown and spinner buttons.
5) Once done with keying In the values click on the set query button to proceed with the configure interface
6) See the below screen for the configure query forms in figure 37 A3.
7) The form has five tabs. Data in each tab must be filled in depending on the choice of the expert.

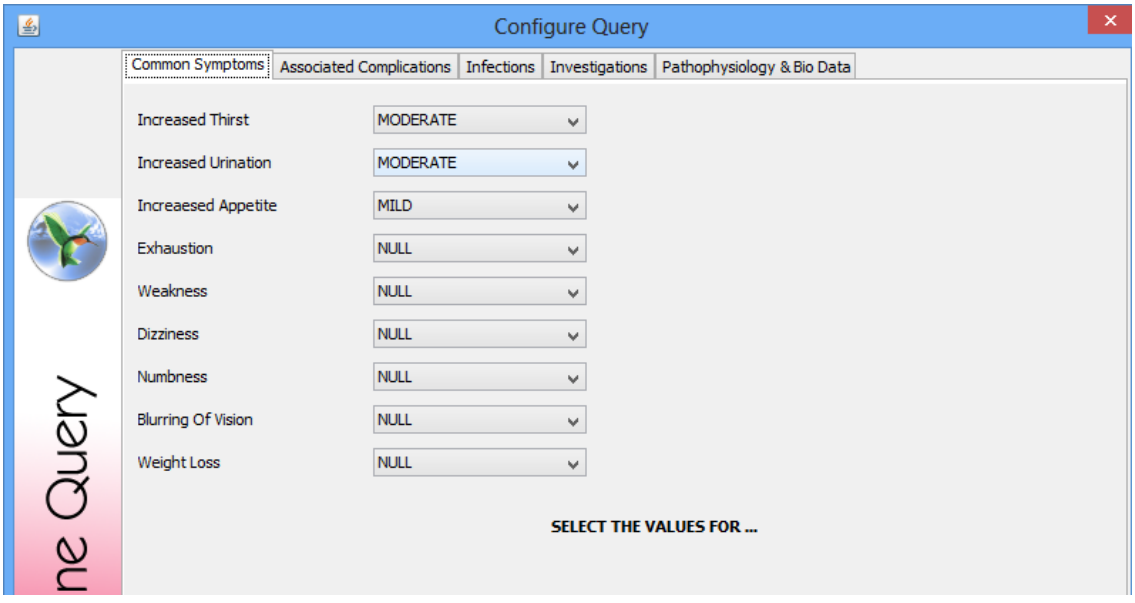

Figure 36 A3 :Configure Query Interface

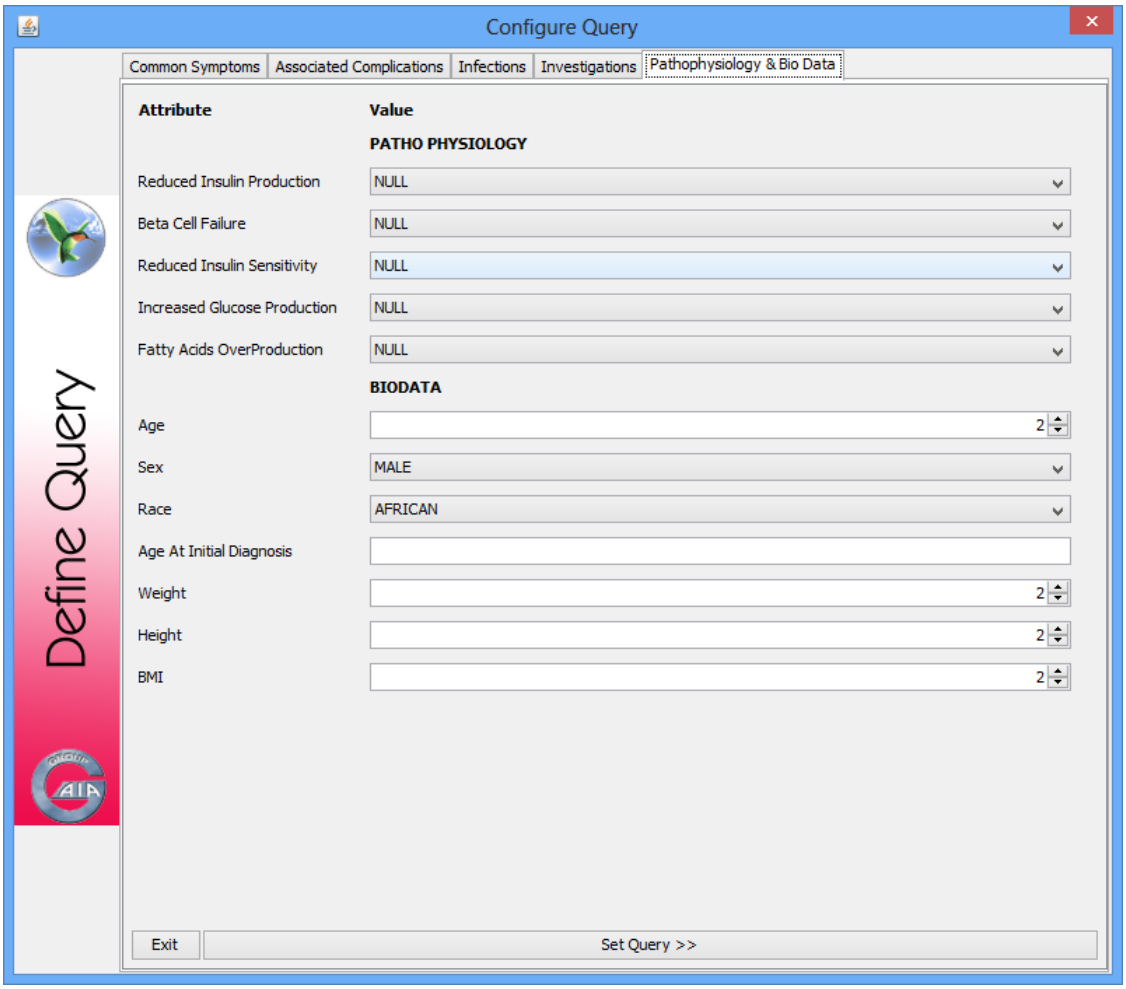

Figure 37 A3:Common Symptoms Dialog

8) To proceed to the similarity phase of the application click on the next button under the pathophysiology & biodata tab as shown below in figure 38 A3

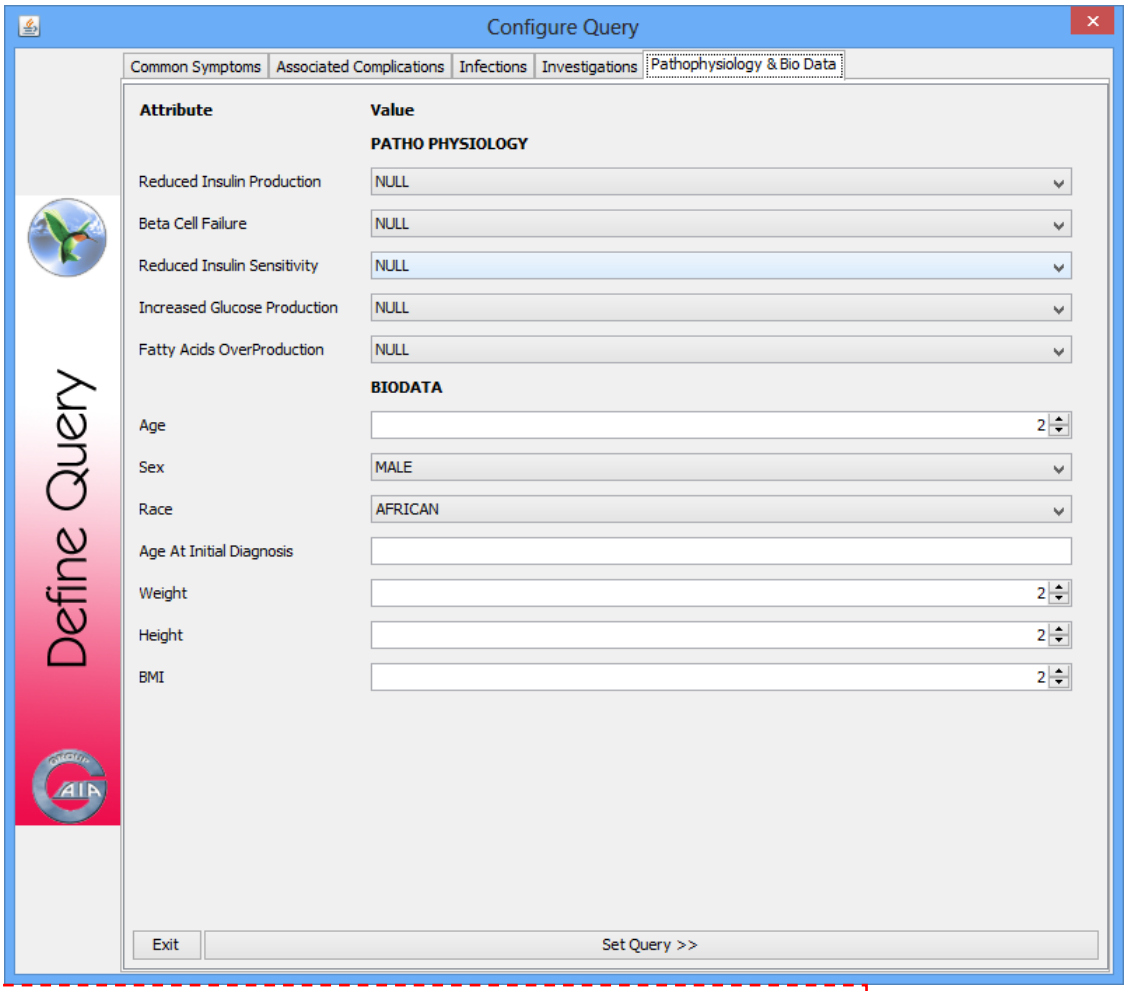

Figure 38 A3:Configure Query Pathophysiology & Bio Data

Configure similarity

The configure similarity interface assist in setting the weights of each of the values entered in the configure query screen. The global similarity is $0<x<1$ for each case.

Steps;

1) Launch the configure similarity interface.
2) Enter the weight of each value by moving the slider bars. When the slider is on the extreme left the weight of the attribute is least sigficant and vice versa. See the

below diagram .E.g. the weight of the Increased thirst symptom has been set to 50 % as illustrated below in Figure 39 A3

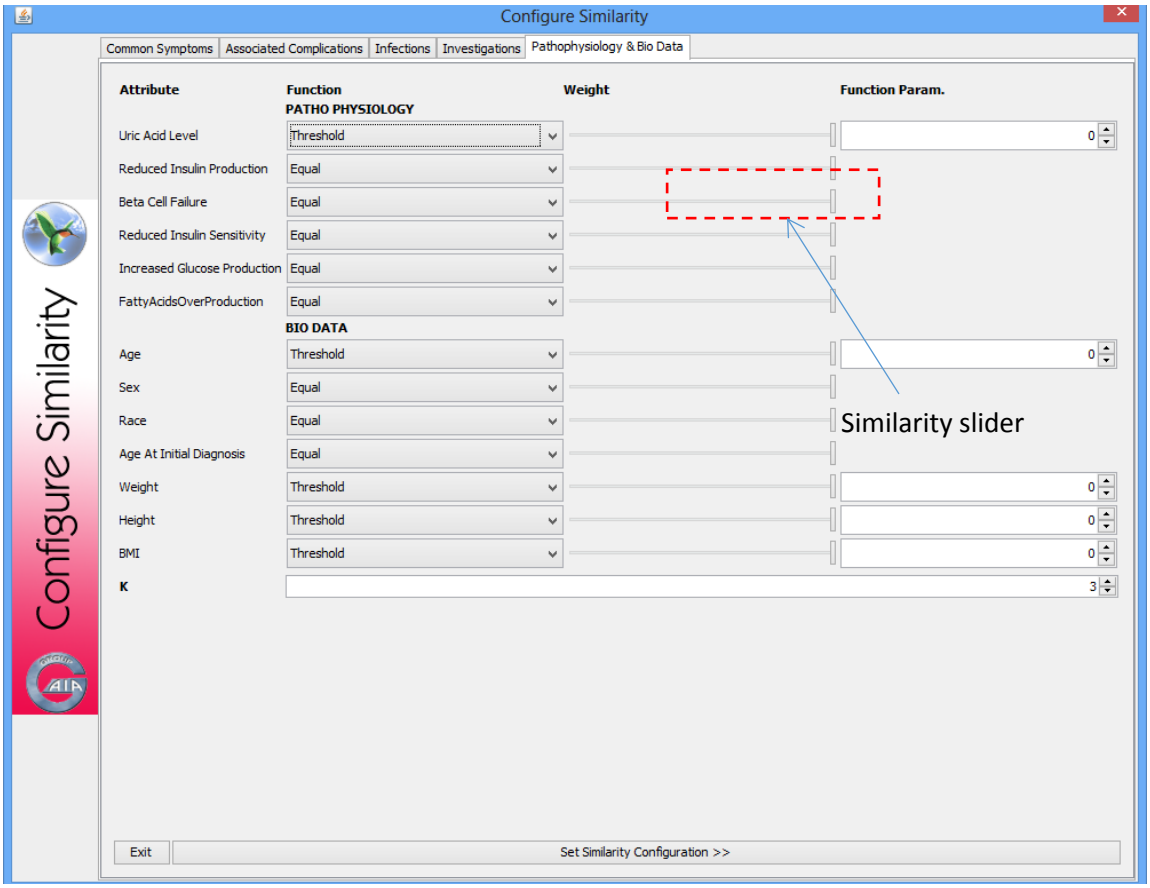

Figure 39 A3:Configure Similarity Weight Slider Bar

3) The value of the attribute can be an interval, threshold or an exact value.
4) The K value provides the number of cases to be retrieved.
5) Once done with the weight for each of the attributes of the case press the set similarity configuration button as shown below in figure 40 A3 under the pathophysiology & Biodata tab as indicated by the form .

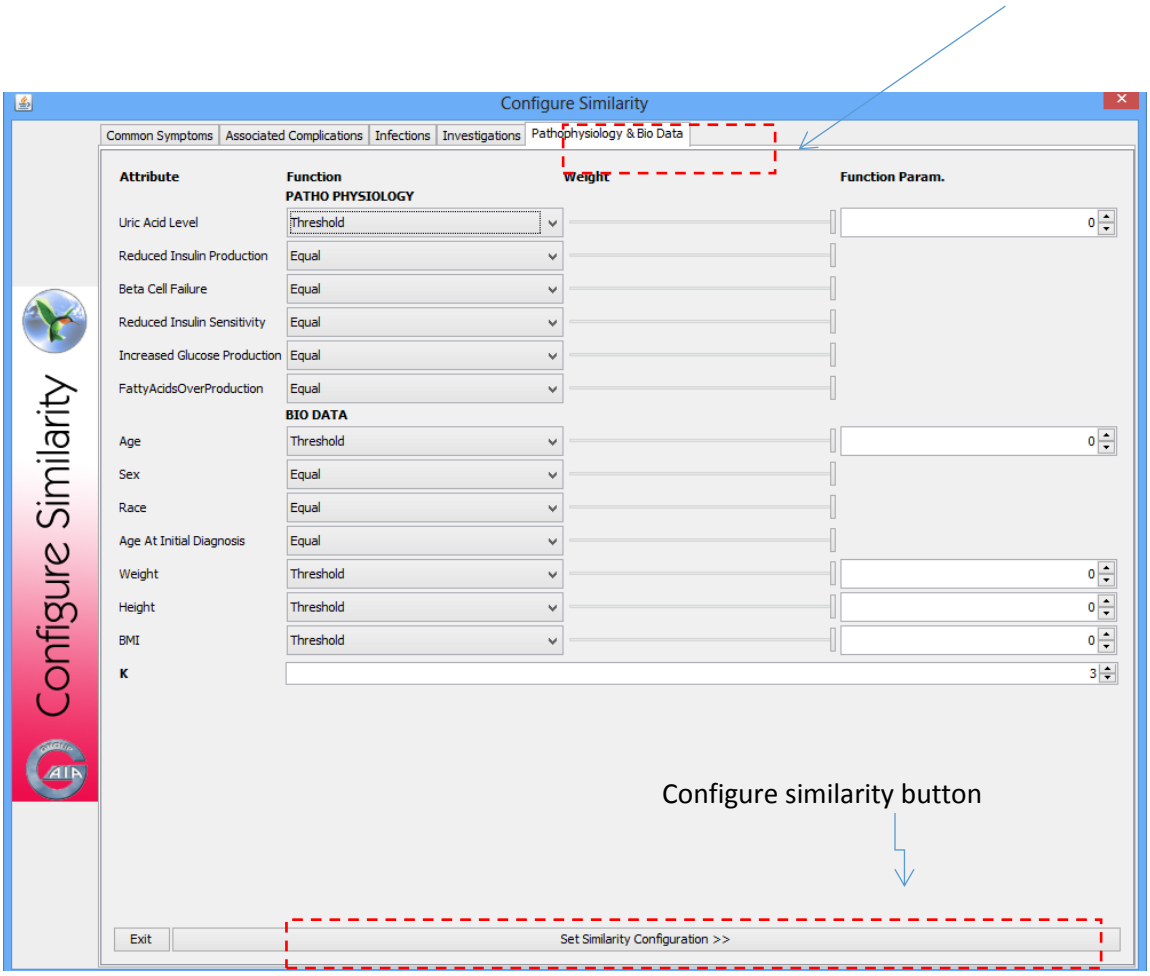

Figure 40 A3: Configure Similarity Number of Cases to retrieve Dialog

6) The application displayed the retrieved cases dialog interface.

Retrieved Cases Interface

The retrieved cases dialog displays the scored cases .The cases are listed beginning with the one with the highest similarity to the one with the lowest similarity.

1) The retrieved cases are displayed each with its own similarity value. Ranging from 0 to 1 . $0<X<1$. The case with an exact similarity displays a 1 and the one with the least similarity a 0.

2) To scroll through the retrieved cases use the scroll buttons. The backward button scrolls towards the case with highest similarity
3) Each is made up of the problem description and its solution.
4) The problem description is defined under the a) Common symptoms b)Associated Complications c) Infections d)Investigations e) Pathophysiology & Biodata tabs .
5) And the suggested solution is set under the solutions tab as highlighted in dotted marks illustrated below in figure 41 A3

Figure 41 A3:Retreived Cases Dialog

6) The similarity of each case is also highlighted. The nearest neighbor to the described problem has the highest similarity of 1 and the farthest least matching a similarity of 0. See below figure 42 A3 for illustration

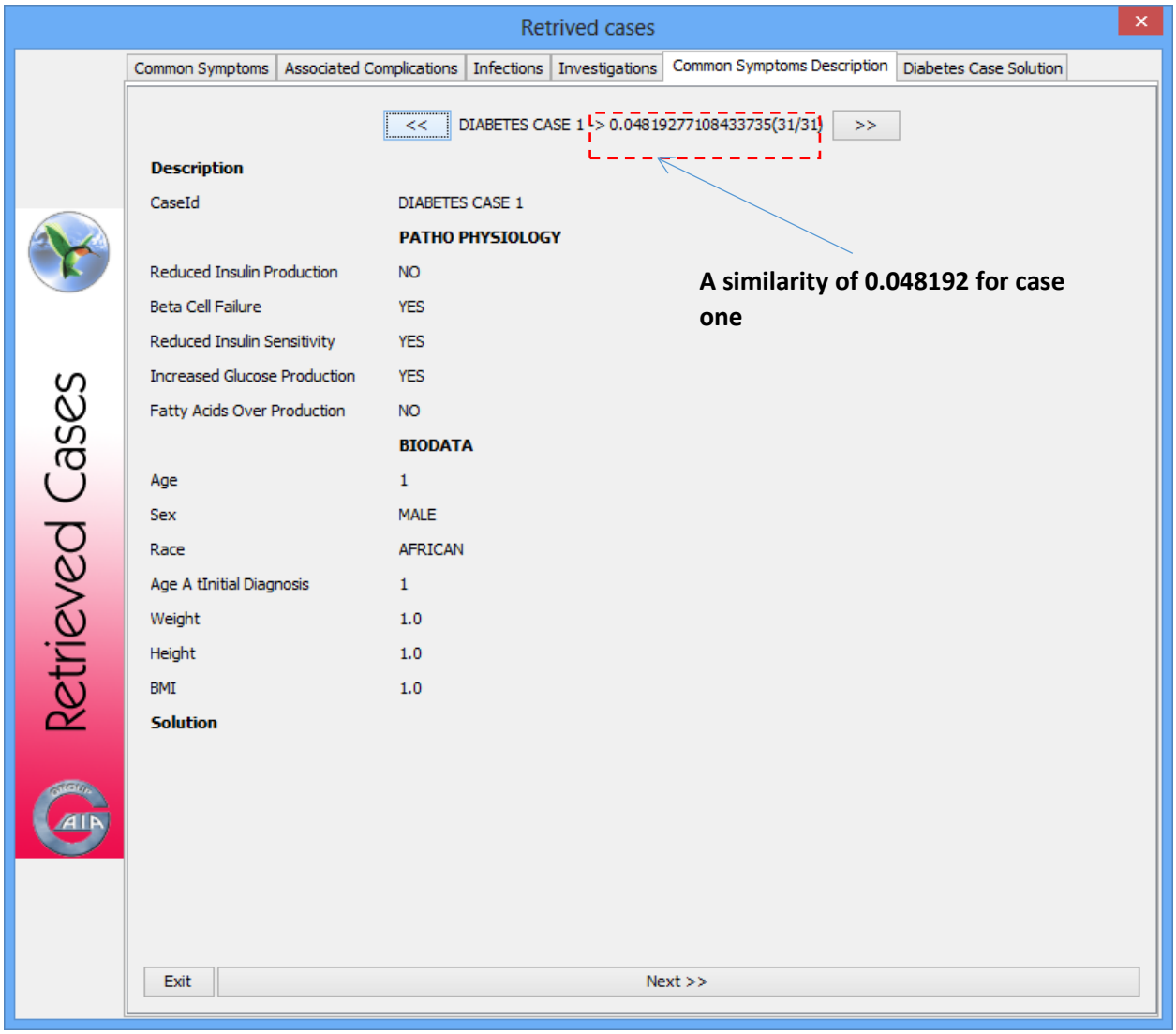

Figure 42 A3:Retrieved Cases Similarity

7) Click on the next button to move on to the next screen of adaptation illustrated below in figure 43 A3

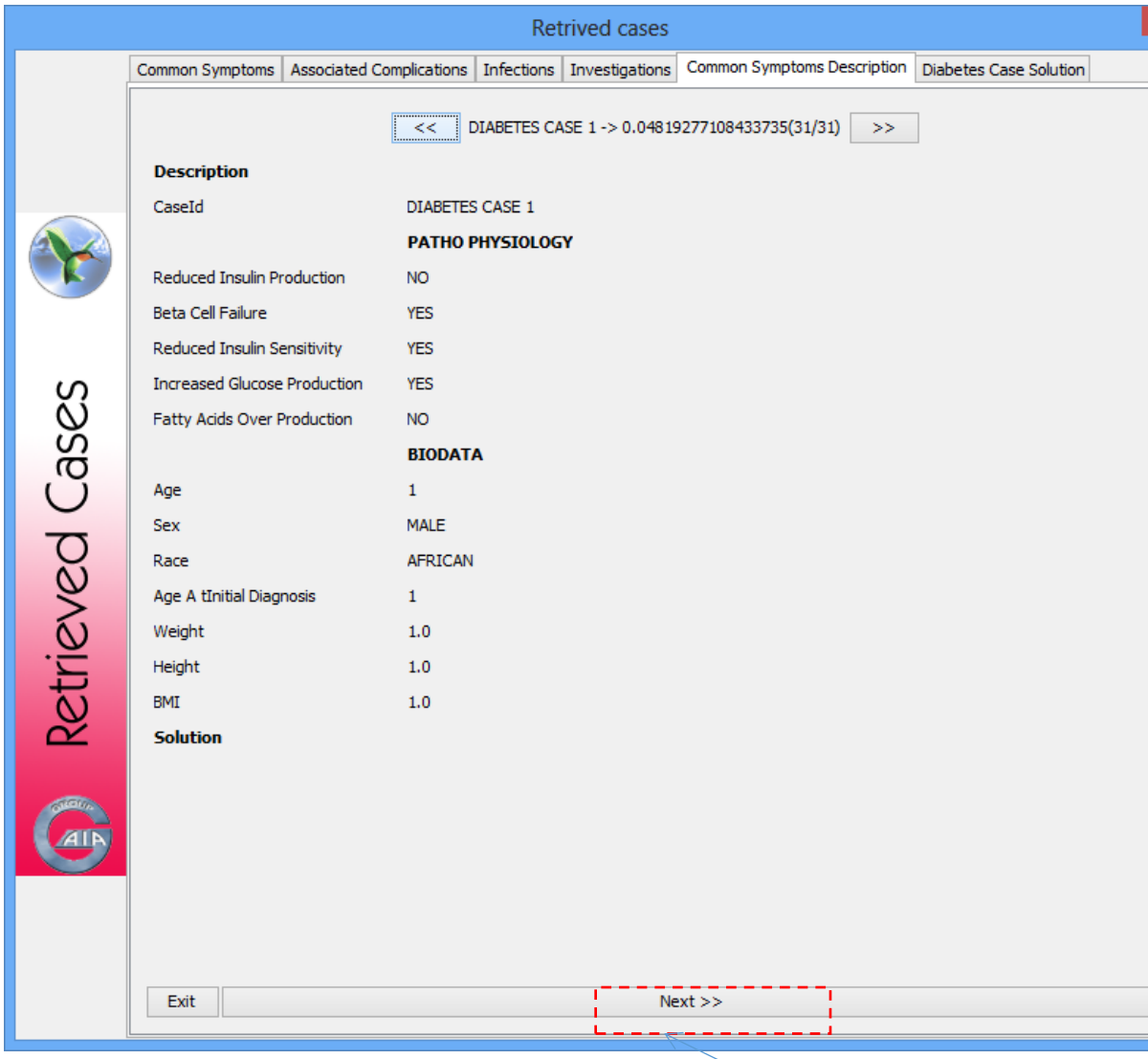

Figure 43 A3:Display Solution DialogRetrieved Cases Form.

Adaptation & Retain Interface.

The adaption interface provides a user with the screen to modify the cases

1) Click on the adapt the cases button to display the adapt cases interface as shown below in figure 44 A3

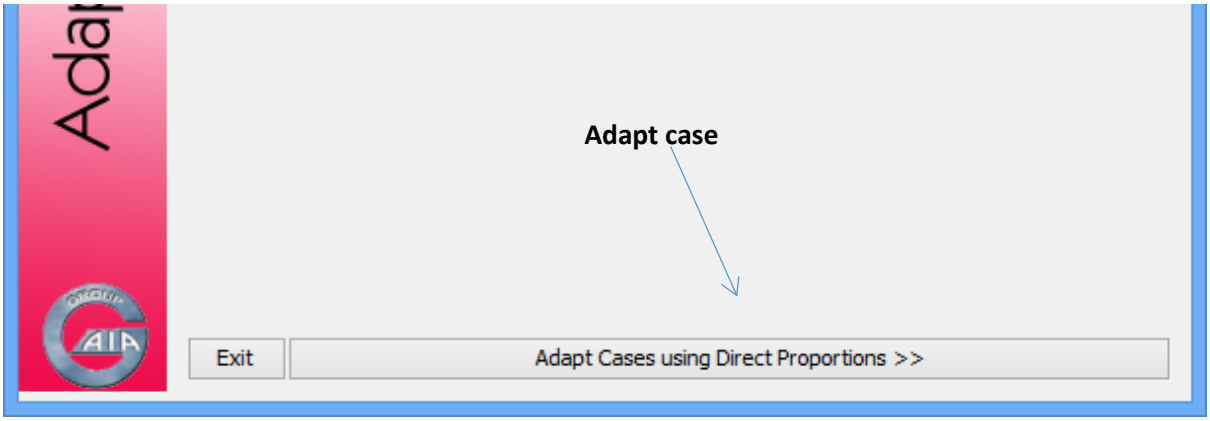

Figure 44 A3: Adapt Cases Interface

2) Scroll to the case that you need to adapt.
3) Enter the new values to modify the new cases.
4) You can either modify the problem description or the Solution of the case if the suggest solution retrieved above does not resolve the problem
5) Once done click on the set revision button as illustrated in figure 45 A3 below

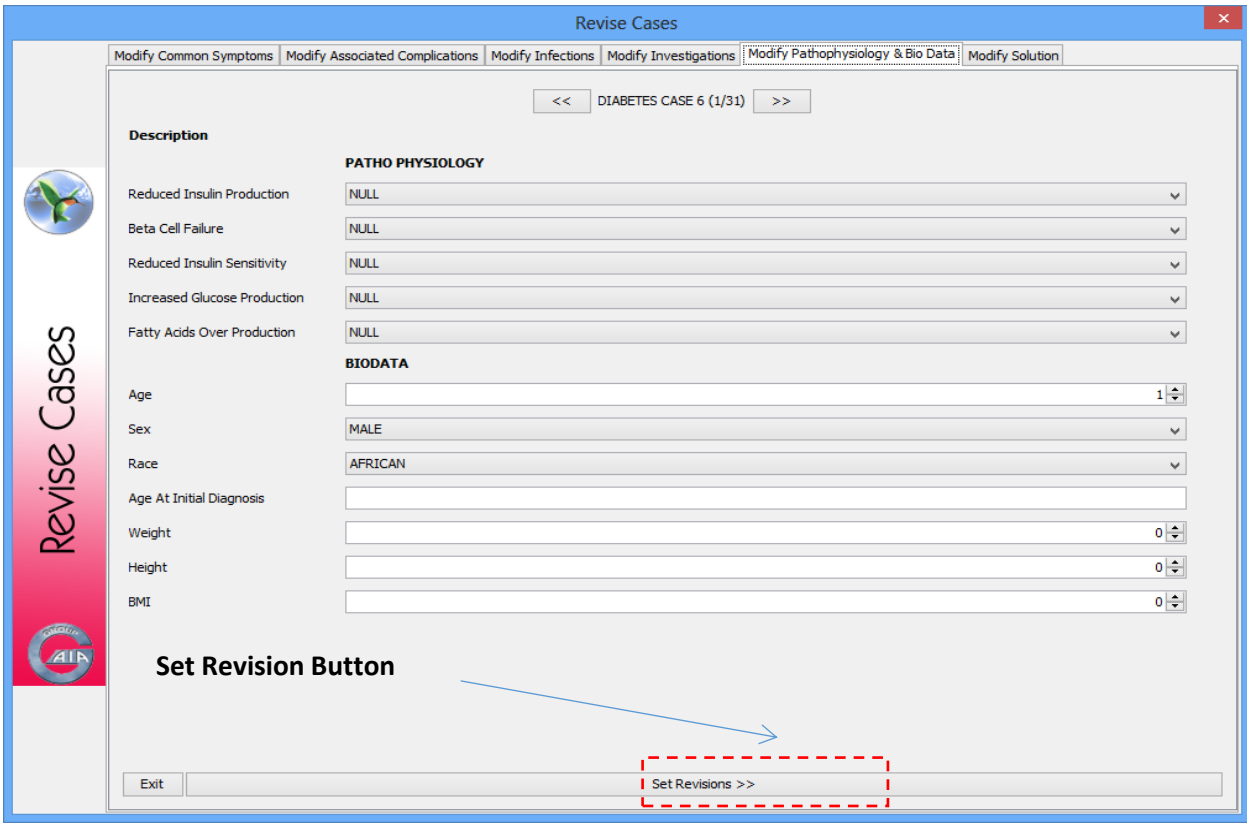

Figure 45 A3:Retreived Case Dialog Interface

6) The case to be modified is displayed .
7) Check on the Save Case with new id button
8) A case id text field is activated.
9) Click on the apply button to save the case as highlighted below in figure 46 A3

Retain Cased Interface Form

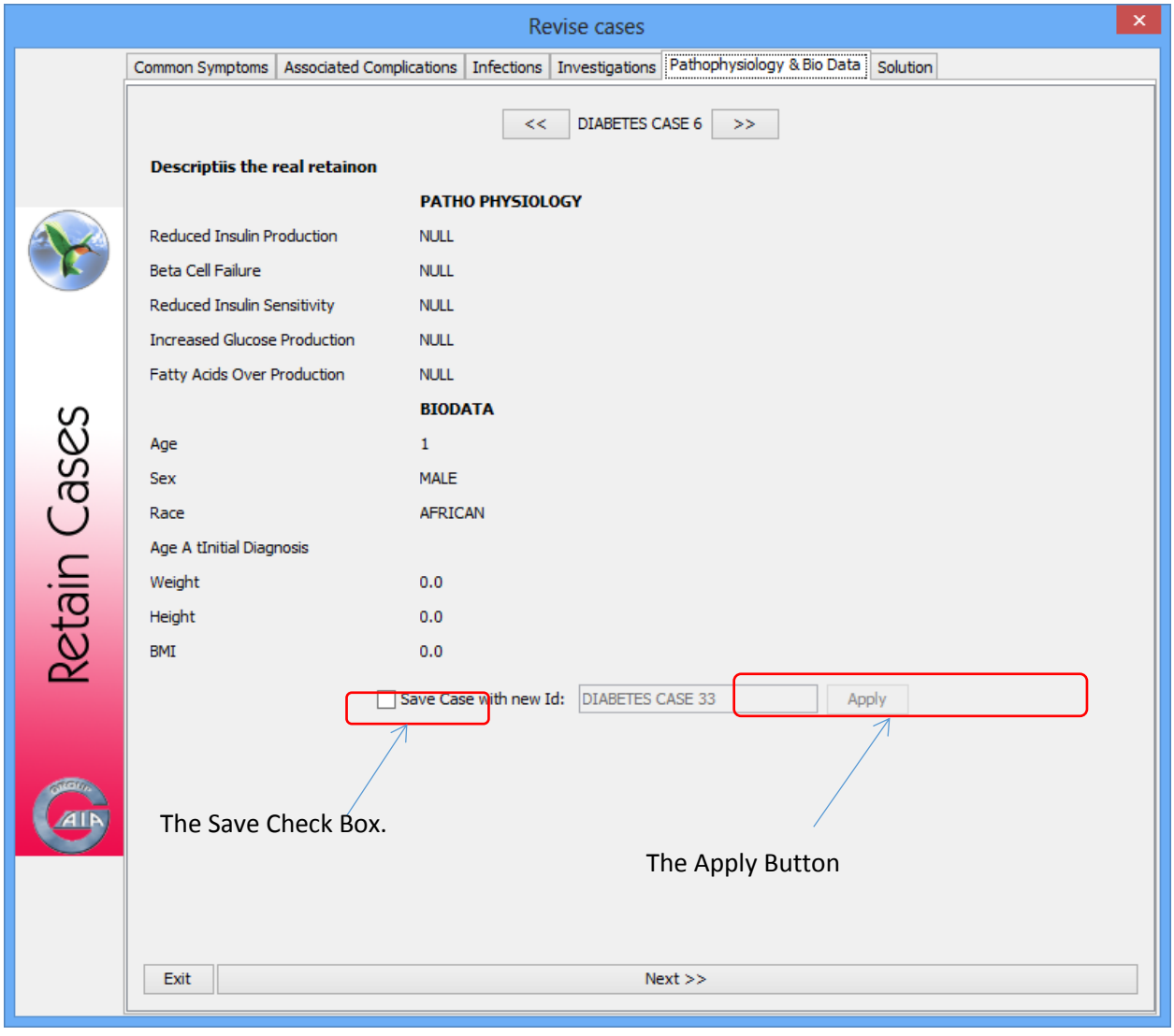

Figure 46 A3:Retain Case Dialog Interface

Appendix 4 Test cases.

i) Configure query dialog

Precondition.

The query dialog is displayed and visible to the user. Table 18 A4 below show the steps undertaken to review the configure query dialog. Interface as the 1st cycle of CBR.

Table 18 A4: Test Case for the query dialog

Test case	**Test case Name**	**Test case description**	**Test case steps**		
			Steps	Expected	Actual outcome
Test case one	Query dialog test case	To ascertain that the configure query dialog functions as per the requirements	Launch the query module by clicking on the car icon on the desktop	The CBR should launch the configure query dialog	The CBR launches the configure query dialog
			Select the values from the dropdown and enter the values by use of the spin boxes provided	The dropdown and the boxes should provide a list of values and the spinner should accept the values entered by the expert	The dropdown provides the necessary values in form of a dropdown and allow the value entered by the expert to be captured
			The interface organizes data into the following categories. a) Common symptoms b) Associated with complications c) Frequent infections d) Investigations e) Pathophysiology f) Biodata	The interface for the configure query should group the data into the following categories	The interface displays data into the categories as indicated from a to f.

			Press the exit button to close the configure query dialog	The configure query interface should close when the user presses the exit button	The configure query dialog closes when the exit button is pressed.
			Move to the configure similarity interface by pressing on the set query button on the configure similar button	The application should display the configure query interface	The application displays the configure query interface

ii) Configure Similarity.

iii) The configure similarity test cases steps highlighted in table 19 A4 shows the review done to confirm 2nd cycle of the CBR.

Table 19 A4: Test Case Configure Similarity

Test case	Test case Name	Test case description	Test case steps		
			Steps	Expected	Actual outcome
Test case two	Configure similarity dialog test case	To ascertain that the configure similarity dialog functions as per the requirements	Launch the configure similarity dialog by clicking on the set query button.	The CBR should launch the configure similarity dialog	The CBR launches the configure similarity dialog
			Set the values for the similarity from the dropdown and the weights from the slider bars.	The dropdown and the slider bars should provide a list of equality values and the slider bars should provide for the adjustment of the weight	The dropdown provides the necessary values in form of a dropdown and allow the value entered by the expert to be captured
			Press the exit button to close the	The configure	The configure similarity

			configure similarity dialog	similarity interface should close when the user presses the exit button	dialog closes when the exit button is pressed.
			Move to the retrieved cases interface by pressing on the set configuration similarity button	The application should display the retrieved cases interface	The application displays the retrieved cases interface

iv) Retrieved cases

The retrieved cases test case was done to review the viability of 2rdcycle of CBR reasoning see table 20 A4 for the illustration

Table 20 A4: Test Case for retrieved cases

Test case	Test case Name	Test case description	Test case steps		
			Steps	Expected	Actual outcome
Test case three	Retrieved interface test case	To ascertain that the retrieved dialog functions as per the requirements	Launch the dialog for the retrieved cases module by clicking on set similarity configuration button	The CBR should launch the retrieved cases dialog	The CBR launches the retrieved cases dialog
			Select the values from the dropdown and enter the values by use of the spin boxes provided	The dropdown and the boxes should provide a list of values and the spinner should accept the values entered by the expert	The dropdown provides the necessary values in form of a dropdown and allow the value entered by the expert to be captured
			Click on the pagination button to scroll through the cases.	The weights of the retrieved cases	The weights of the retrieved cases are

				should be displayed in ascending order of their values**.** (nearest neighbor)Starting with the one with highest similarity	displayed in ascending order of their values**.** (nearest neighbor)Starting with the one with highest similarity
			Scrolling through the cases retrieved by use of the pagination buttons	The interface should provide a way to scroll through the retrieved cases by use of the pagination buttons.	The interface provides a way to scroll through the retrieved cases by clicking on the pagination button
			The retrieved cases interface organizes data into the following categories. a) Common symptoms b) Associated with complications c) Frequent infections d) Investigations e) Pathophysiology f) Biodata	The retrieved cases interface should group the data into the following categories	The retrieved interface displays data into the categories as indicated from a to f.
			Press the exit button to close the retrieved cases dialog	The retrieved cases interface should close when the user presses the exit button	The retrieved cases dialog closes when the exit button is pressed.

v) Adapt case Test case

The 3rd cycle of case modification test cases were conducted as indicated as shown in table 21 A4 below.

Table 21 A4: Test Case for the case Adaption

	Test case Name	Test case description	Test case steps		
			Steps	Expected	Actual outcome
Test case four	Adapt case test case	To ascertain that the adapt case dialog functions as per the requirements	Launch the adapt case module by clicking on the next button.	The CBR should launch the adapt case dialog interface	The adapt case dialog is launched.
			The interface organizes data into the following categories. a) Common symptoms b) Associated with	The interface for the configure query should group the data into the following categories	The interface displays data into the categories as indicated from a to f.

			complications c) Frequent infections d) Investigations e) Pathophysiology f) Biodata		
			Click on the scroll button to select the case to adapt	The Interface should display the values of the case to be retained.	The application shows the cases to be adapted.
			Enter the new values to be adapted	The interface should provide controls to enter the data needed for the adaptation	The interface provides controls to capture the new data to be revised.
			Press the exit button to close the adapt case dialog	The adapt case interface should close when the user presses the exit button	The adapt case dialog closes when the exit button is pressed.
			Move to the retain case interface by pressing on the set revision button.	The application should display the retain case interface	The application displays the retain case interface

vi) Retain case dialog

The 4th cycle test case of the CBR was highlighted in the steps below shown in table 22 A4.

Table 22 A4: Test cases for Retain Dialog

	Test case Name	Test case description	Test case steps		
			Steps	Expected	Actual outcome
Test case four	Adapt case test case	To ascertain that the retain case dialog functions as per the requirements	Launch the retain case module by clicking on the next button.	The CBR should launch the retain case dialog interface	The retain case dialog is launched.
			The interface organizes data into the following categories. a) Common symptoms b) Associated with complications c) Frequent infections d) Investigations e) Pathophysiology f) Biodata	The interface for the retain query should group the data into the following categories	The retain interface displays data into the categories as indicated from a to f.
			Click on the save case Id	The interface should	The interface activate the

			check box .	activate the field for entering the new case to be retained	field for the case name
			Click on the apply button	The application should capture the new case and retains it for future reuse	The application captures the new case and its retained for future resolutions
			Press the exit button to close the adapt case dialog	The retain case interface should close when the user presses the exit button	The retain case dialog closes when the exit button is pressed.
			Click the next button to repeat the 4Rcycle again	The application should display the 4R cycle dialog interface.	The application displays the 4R cycle interface.

Appendix 5 Test cases.

The formative evaluation questionnaire.

Reasoning Based On Experience

The use of previous experience can be used to support health decisions in treatment and management of diabetes see table 23 A5 for illustration of the questionnaire design.

Table 23A5: Previous experience can be used to support health decisions

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
Experienced Doctors Take less time to make clinical decisions					
Experienced Doctors Make better Diagnosis & Treatment Plan					
Patients managed by experts record less fatalities.					

2. Experience can be used to avert potential adverse risks in provision of health care to diabetic patients see table 24 A5 for the questionnaire design

Table 24A5: Potential adverse risks

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
Experienced doctors record less patient fatalities					

3. We can help in planning management by referencing previous cases see below table 25 A5 for the questionnaire design

Table 25 A5: Planning management

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
We can estimate intervention time by referencing past cases.					
Previous cases can help in estimating					

management costs.					

4. Past solutions can be used as answers for current problems see table 26 A5 for the questionnaire design.

Table 26 A5: Past solutions can be used as answers for current problems

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
There are situations where you copy past solution to be applied to the new case					

5. Prevalence of diabetes in Kenya see the below table 27 A5 for the questionnaire design

Table 27 A5: Prevalence of diabetes in Kenya

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
The Number of diabetes cases in **Kenya** has increased					

6. In most cases similar diagnosis has similar treatment & management options see the below table 28 A5 for the questionnaire design

Table 28 A5: Similar diagnosis has similar treatment

	Strongly disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly agree
There exists an interdependence between conditions and symptoms					
A diabetes diagnosis, management& treatment plan can be reused					

7. A computer software can be used as a tool to support clinical decisions see the below table 29 A5 for the questionnaire design

Table 29 A5: A tool to support clinical decisions

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	**Strongly Agree**
It is possible to automate clinical decision					

8. Novice are as effective as professionals in making in medical decisions see the below table 30 A5 for the questionnaire design

Table 30 A5: Novice are as effective as professionals

	Strongly Disagree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly Agree
Advanced conditions are better treated by experienced medical experts					

Appendix 6 Test cases.

The summative questionnaire evaluation.

CBR Tool For Diabetes & Management Evaluation Questionnaire

Thank you for participating in our survey. Your feedback is important. We want to hear from you whether the Diabetes experience management tool helped to capture previous cases and whether the software assisted in quickening diabetes medical decisions.

1. **Address see below table 31 A6 for the feedback questionnaire design.**

Table 31 A6: Demographic Details of the Respondent

Name		
Company		
Email Address		

2. How easy is it to use the software see below table 32 A6 for the easy of use questionnaire design.

Table 32A6: Easy of use questionnaire

	Strongly Agree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly Agree
It is Simple to use					
It is User friendly					
I use the software successfully every time					

Is the software easy to use if you have disagreed above kindly share the reason?

_____

_____

3. Satisfaction

See table 33 A6 below for the satisfaction questionnaire design.

Table 33 A6 Satifistcation Questionnaire

	Strongly Agree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly Agree
I am satisfied with the software					
It is fun to use the software					
It is wonderful					

4. Do you think that the interface is easy to use

□ YES

□ ***No***

Share your Comment regarding the choice you made above.

---

5. Is the Software Interesting?

□ YES

□ No

Share your Comment regarding the choice you made above.

_____

_____

_____

6. What features of the software did you find most useful

_____

_____

_____

7. What would you want to add to the software to make it more useful

_____

_____

_____

8.) What would you want to remove from the software to make it better

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9. Functionality Test

See the below table 34 A6 for the functionality questionnaire design.

Table 34A6: Functionality Test Questionnaire

	Strongly Agree	Slightly Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly Agree
Do you think this software can be used to improve on medical diabetes interventions					
Do you think this software can be relevant to predict potential risk in management of diabetes					
Do you think this software can be relevant in justifying medical judgements?					

10. Usefulness of the CBR tool for treatment and management of diabetes.

See table 35 A6 for the usefulness questionnaire design.

Table 35 A6: Usefulness Questionnaire

	Strongly Agree	**Slightly Disagree**	**Neither Agree Nor Disagree**	**Slightly Agree**	**Strongly Agree**
I become more effective when using the software					
I am more productive when using the software					
It makes it easy for me to make clinical decisions					

Appendix 7 Experts used to review the system

A total of 10 experts listed in table 36 A7 below were used to review the system.

Table 36 A7: Number of Experts Interviewed

NO of Experts	**Title**	**Health Care**
3 Doctors (Dr. Leonard Mutembei) referred by Leonard	Doctors	Safaricom
1(Joseph)	Clinical Officer	Diabete Management Institute
1 (Atieno)	Clinical Officer	Diabetes Association of Kenya
1 (C.O Steve Muema)	Clinical Officer	Kenyatta National Hospital
1 (C.O Brian Mundi	Clinical Officer	Nairobi Women's Hospital
1 (Dr. Kuria)	Doctor	Gilfilan Hospital
1 Dr. Masawa	Doctor	Avenue Hospital