Decision Support System for Dengue Management Based on Vital Signs and Blood Profile

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March 2019

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Dissertation submitted to the Faculty of Information Technology, University of Moratuwa, Sri Lanka for the fulfillment of the requirements of Degree of Master of Science in Information Technology.

March 2019

Declaration

I declare that this thesis is my own work and has not submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from published or unpublished work of others has been acknowledged in the text and a list of lists of references is given.

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Acknowledgements

First and foremost, I would like to convey my utmost gratitude to my project supervisor Mr. S.C Premaratne, Senior Lecturer in University of Moratuwa, whose expertise, understanding added considerably to my research experience and Professor Harendra de Silva, Senior Professor of Paediatrics, Colombo, for their guidance, encouragement and inspiration throughout my research work. Without the precise guidance I had from them I could not have succeeded anyway.

In addition to those, I would like to offer my sincere appreciation to all the lectures of M.Sc. in Information technology degree program the of Faculty of IT, who sharpens our knowledge and ideas throughout this M.Sc. Program and all the batch mates of the M.Sc. in IT degree program who gave their valuable feedback to improve the result of research and my family for the support they provided me.

Abstract

Dengue is a mosquito-borne viral disease which has become a major health issue in Sri Lanka during the past few years. Based on the symptoms and their severity dengue can be classified as Dengue Fever (DF), Dengue Haemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS). Being a viral disease, it cannot be cured with drugs and attempts to develop a vaccine have not been successful yet. Therefore, proper care and management have become very critical to reduce the number of dengue deaths. Plasma leakage is the major reason which causes death from dengue virus and correct identification of plasma leakage is a challenging task for medical doctors. Since there is not specific available treatment for dengue, early detection of the suspected case and give proper medical care can help to prevent dengue shock or severe involvement.

This research based on research paradigm, Cased-Based Reasoning (CBR) to develop a web application to manage dengue illness. Identified most important cases related Dengue and identified rules which are related to those rules. Clinical parameters and values or ranges of those parameters are used for this research with the guidance of the Physicians. Based on these cases and rules, the system is developed. The system will predict the current situation of the patient by analyzing his/her past vital signs and blood profiles. Normally Dengue Patients are monitored hour by hour and some of those important monitoring parameters will be entered to the system. Then the system will display the current stage of the Dengue and some suggestions. And using this system doctors can see how is the Pulse Pressure, Urine Output, Packed Cell Volume (PCV), Platelet Count and White Cell Count (WCC) varying according to the time of the particular patient.

The system generated details will help doctors to identify the current situation of the patient and do proper treatment to the dengue patient. This will help to reduce the number of Dengue death in Sri Lanka.

Table of Contents

List of Figures

List of Tables

Abbreviations

WHO	Word Health Organization
DF	Dengue Fever
DHF	Dengue Haemorrhagic Fever
DSS	Dengue Shock Syndrome
HR	Heart Rate
PP	Pulse Pressure
HCT	Haematocrit
UOP	Urine Output
WCC	White Cell Count
CBR	Cased Based Reasoning
PCV	Packed Cell Volume
IV	Intravenous

Chapter 1

Introduction

1.1 Prolegomena

Dengue is one of the most rapidly spreading mosquito-borne viral infections endemic in tropical and sub-tropical regions around the world. Infection of Dengue fever is caused by female mosquitoes mainly of the species Aedes Egypti and Albopictus. In the first half of 2017 alone, 80 732 dengue cases, with 215 Dengue deaths were accounted for in Sri Lanka [1].

Dengue virus infections may be asymptomatic or may lead to undifferentiated fever, dengue fever (DF) or Dengue Hemorrhagic fever (DHF) with plasma leakage that may lead to Dengue shock syndrome (DSS) [2].

General behavior of dengue infection as below. Assume the 10,000 people have dengue infection. Out of them 9,000 people belong to Asymptomatic group. They don’t have a fever and syndrome. But they have dengue virus and spread dengue virus to others. 500 from the remaining 1,000 have a viral fever with decreasing White Cell Count (WCC) and normal platelet count. After one week, still they have doubt of Dengue or NS1 antigen is positive do antibodies. 400 from the remaining 500 have Dengue Fever with decreasing White Cell Count (WCC) and decreasing Platelet count but no leakage. The remaining 100 have DHF with leakage. During this research mainly focused on DHF patients whose NS1 antigen is positive.

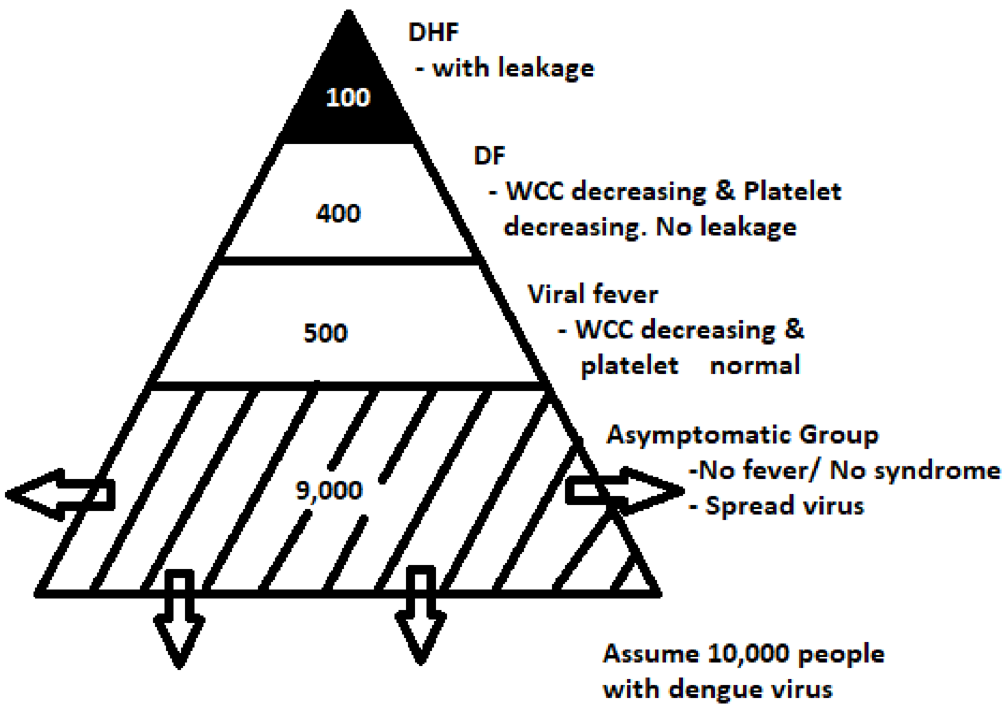

Figure 1.1 - Dengue Virus Infection

In some cases, Dengue is an asymptomatic. This does not mean that people do not show symptoms. For those who have symptoms, pain occurs between 4 to 7 days of bites. This infection is caused by the onset of symptoms of the virus, sudden fever of the waves, eyes, muscles, joints and bone pain, headache, and redness of the skin. Supportive care includes symptoms. Antibiotics cannot be treated.

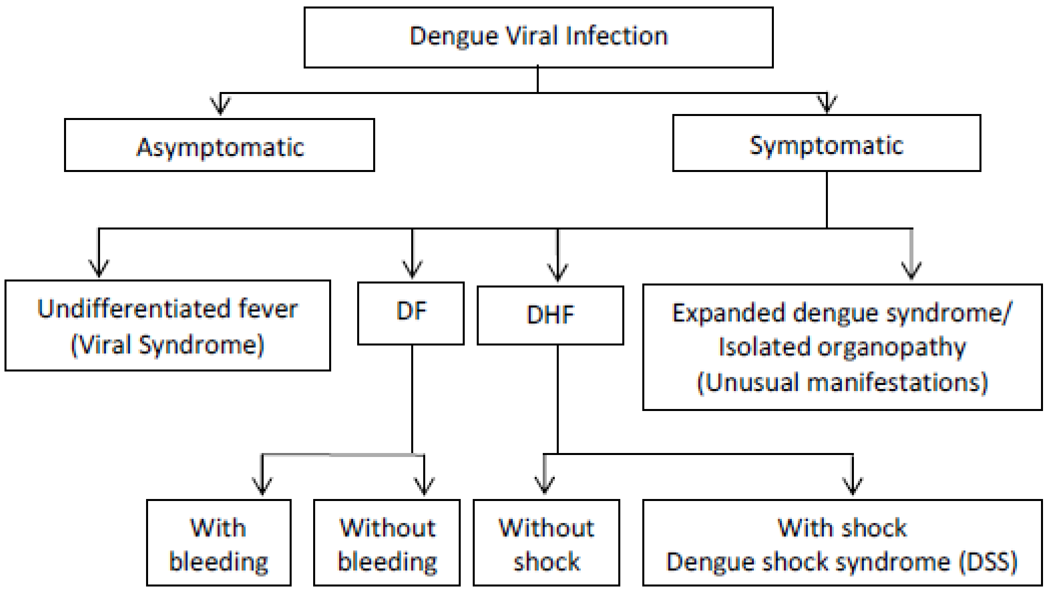

Figure 1.2- Manifestation of dengue virus infection [2]

After 4 to 14 days of onset, the patient has a self-limiting pathological disease with one or more of the following: [3]

- high fever of up to 40°C
- headache
- severe eye pain behind the eye
- nausea/vomiting
- muscle pain
- joint pain
- Rashes

The fever takes about 4-7 days, and with the settlement of the temperature many patients are healed without complications. However, some people go on to develop serious complications within 48 hours around the critical stage of the plasma leak.

After the period of the incubation, the disease starts suddenly and then takes place in three stages: febrile, critical and recovery stage. [4]

- Febrile phase: high grade fever suddenly and usually last 2-7 days
- Critical/plasma leak phase: Sudden variation of plasma leakage into the pleural and abdominal cavities
- recovery phase: During the critical phase between 24-48 hours, plasma leakage is usually exerted and stopped by a highly abnormal reaction

The course of dengue illness as below [5] .

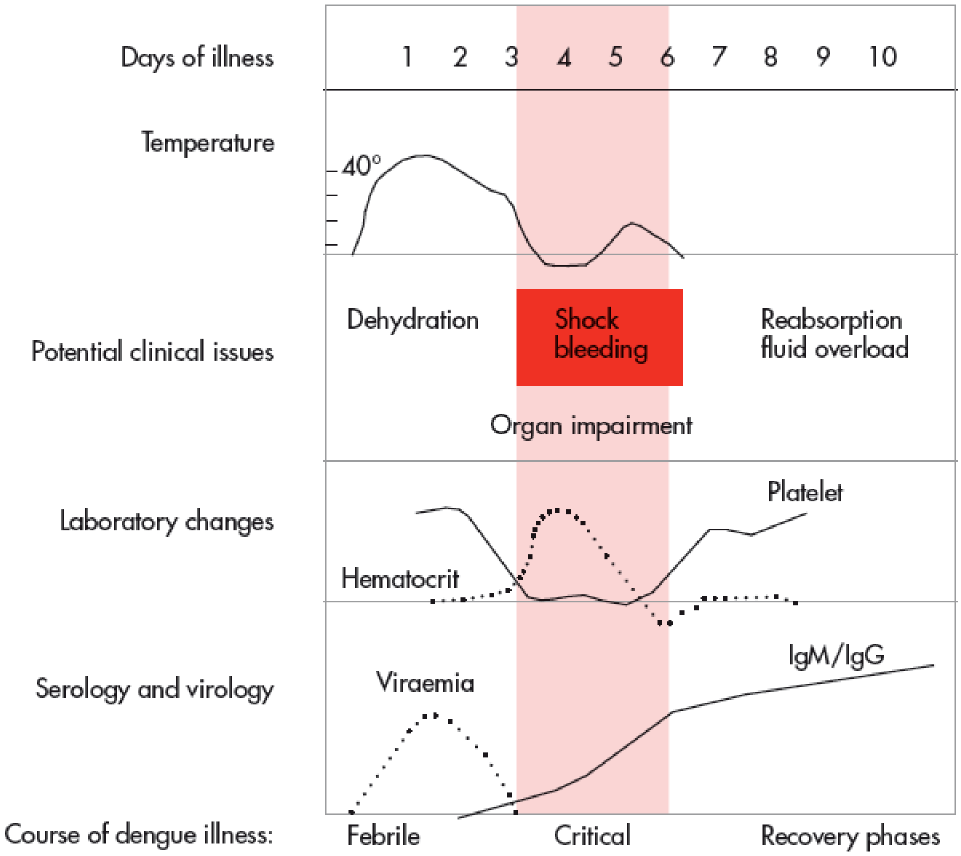

Figure 1.3 -Course of dengue illness

DF begins with a " febrile line" with the fever. Platelets and white blood cells slowly decrease with blood (blood pressure). Thereafter the fever has disappeared and the patient becomes dengue patient. In this stage the platelet counts and WBC plunges dramatically while hematocrit is elevated. Symptoms are severe and can cause dehydration and / or bleeding if the patient is not addressed seriously and promptly, and later susceptible to vomiting and / or death. If the symptoms are minor, the critical stage ends at the 5th or 6th day, the platelets are slowly growing and the patient is perfectly well [6].

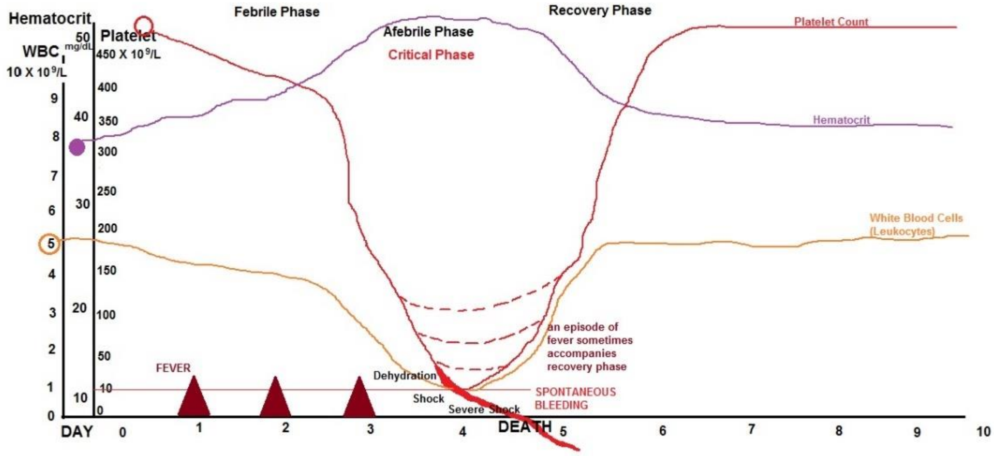

Figure 1.4 - Phases of Dengue with Platelet, WCC and PCV *[6]*

However, often it is difficult to differentiate DF from DHF in the early phase (febrile phase) of disease. When there is a high fever in DHF, it is associated with symptoms in DF at the early febrile stage. Plasma leak is a special sign of DHF that occurs after the febrile stage ends. There is tendency of developing DSS due to plasma leakage. Therefore, the DF and DHF patients should be closely monitored to identify patients with DHF.

The rate of plasma bleeding in DHF may vary. Some patients may be infinite, while others are very important. The leak usually begins gradually and gradually increases, slows down, and finally of leakage phase (usually within 48 hours) [2].

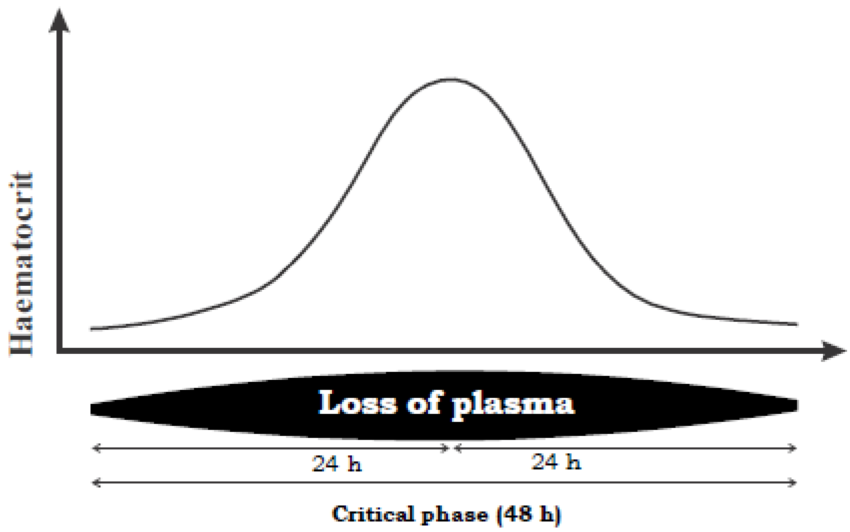

Figure 1-5 - Fluid leakage in the critical phase

The main factors and blood profiles associated with dengue are blood pressure (BP), heart rate (HR), body temperature (BT), packaged cell volume (PCV), platelets (PLT), white blood cells (WBC), urine output and fluid intake rate [5]. Hematocrit (HCT), Platelet (PLT), and Whole Blood Cells (WBCs) are all components of the whole blood test. Dengue virus infected person suffers from high fever. The WHO notes that dengue fever (DF), dengue haemorrhagic fever (DHF) and dengue shock syndrome(DSS) that address on plasma leakage.

Parameter	**Normal Range**	**Critical Stage**
Blood Pressure (mmHG)	120/80	90/60
Heart Rate	80-60	Above 100
Temperature (C)	36.8	Above 36.8

Table 1.1- Ranges of measuring parameters

Appropriate medical treatment and disease management can be identified early in the event of dengue shock or sever involvement. For better dengue patients, the dengue-management model is essential based on vital signs and on blood type. Identifications of most important cases related Dengue and identification of rules which are related to those cases are helped to develop a system to predict the current situation of the patient by analyzing his/her past vital signs and blood profiles.

1.2 Background and Motivation

At present analysis are done with the identification of the different kind of dengue phases to check for the most suitable algorithm or tool that can be used to predict the critical stage of the patient. However, there is no any tool have developed to use in the real world.

1.3 Problem Definition

Increasing the Dengue deaths because of the poor identification of the critical stage of the patient and problems in critical phase management in Sri Lanka.

1.4 Hypothesis

We hypothesize that it is possible to decrease the death of Dengue patient in Sr Lanka with the proper identification of clinical management by using cased based reasoning with web the application.

1.5 The aim of the Research

The aim of the research is designing a system to identify the severity of DHF based on the vital signs of the patient with the correct identification of the plasma leakage.

1.6 Objectives of the Research

Following are the main objectives of the research.

- Identify the nature of the Dengue based on vital signs and blood profiles
- Explore and choose techniques to experiment with vital signs and blood profiles of Dengue patients
- Analyze data and correct identification of plasma leakage
- detection of the plasma leakage as early as possible of the patients who will go into critical phase
- Identification of the various phases of Dengue and identify how the vital signs and blood profiles behave in those phases
- Implement a decision support system to manage dengue

1.7 Summary

This dissertation contains of 8 chapters where the first chapter contains an introduction to the project. A literature survey has been carried and a literature review based on that survey has been included in chapter 2. Chapter 3 covers the theoretical background of the research. Forth chapter focuses on describing the process of implementing the program and its background. Variations of vital parameters of obtained data have been represented in chapter 5. In chapter 6 simulation and experimental results are given. Chapter 7 is the discussion, where the problems faced through study and another approaches tried out for study have been discussed. Finally, chapter 8 gives conclusions and directions for future work.

Chapter 2

Literature Review

2.1 Introduction

Dengue leakage diagnosis and clinical management after the identification of leakage state are the major problems in medical application. In recent years machine learning methods have been widely used in Dengue diagnosis.

2.2 Current methods for Dengue detection

Dengue virus can be diagnosed by detection of dengue virus NS1 antigen and immunoglobulin M (IgM)/IgG antibodies. There is a tool kit called, SD Dengue Duo rapid test kit [7]. Dengue virus NS1 antibodies and infrared IgM / IgG antibodies have been designed for human consumption. An NS1 antibiotic is usually found from day 1 to day 9 after starting the fever. However, the initial dengue fever can be detected from IgM from 3 days to 5 days, and by Day 1 to Day 2 after onset of illness in secondary infections. The Dengue Eye Expert Kit is useful for identifying rapidly the spread of dengue. SD Dengue Duo rapid test kit is useful for the rapid, early diagnosis of dengue infections. The current evaluation of the SD Dengue Duo NS1/IgM shows that this assay has a sensitivity of 88.65% (95% CI: 84.04–93.26), a specificity of 98.75% (95% CI: 96.26–100) with an assay efficiency of 91.70%. By detecting both NS1 and IgM in dengue infection has shown that the SD Dengue Duo rapid test kit is useful, sensitive, and specific for the diagnosis of acute dengue infection.

WI-MON [8] is Wireless Networking and Wi-Mon Software. It measures the critical parameters, such as temperature, blood pressure, pulse rate and ECG. Analyzes the patient's reading. It provides a great deal for remote monitoring tasks. They will be able to access or access the data of patients in any place at a medical center in the medical profession. But there are shortcomings such as low security, not reliable but fast.

A Preliminary Dengue Fever Prediction Model [9] is used to find the result of the patients' severity of dengue infection. The Matlab's statistical toolbox used the formatting and assumption for a classroom learner. Training models include paint trees, variations analysis, support datasets, logistic recruitment, and neighboring classifications. This model was trained using 30 data from dengue patients. Healing pressure (BP), pulse pressure (PP), HR, BT, HCT, PLT, and finally WBC. The severity is divided into three groups. one is for dengue fever without warning signs (DF). Two is dengue fever with warning signs (DFWS) and three is severe dengue (SD). The user / clinic allows the developed GUI to test the severity of the dengue patient. After entering important GUI tables and entering the values of the blood profile, a response to the classification of the dengue fever response will be addressed. But the accuracy of the test data was 50% with a 50% error. Therefore, this method provides low accuracy during the verification.

Fuzzy Inference System (FIS) [10] was designed to early diagnosis of dengue disease. The most commonly used artificial intelligence in medicine (AIM) system is that a patient can obtain a definitive conclusion by using certain data. Fuzzy logic builds on human rights rules provided by users. Their designed system is based on the clinical data base in South Taiwan's clinical data base. This database has resulted in various physical symptoms of the dengue patient and the dengue patient's medical tests. MATLAB's most powerful logical toolbox looked at the eleventh probability variables and one output variant using the theoretical logical toolbox. The decision-making method is useful for the dengue fever(DF), Dengue hemorrhagic fever (DHF) and Dengue shock syndrome (DSS) are not classified as risky ones. The inputs parameters of the system's planned inputs are insufficient for that purpose, since the input classification is required based on input parameters.

A Belief Rule based Expert System to Diagnose Dengue Fever under Uncertainty The system uses a traditional method used for the dengue epidemic, usually not performed by doctors. The standard method of dengue control is HCT, WCC, and blood samples for plucking platelets. Avoiding the risk of dengue fever and avoiding the risk of dengue fever is an aversion to dengue fever. This approach is based on the signs, symptoms and risk factors of dengue fever such as Fever, Headache, Rash, Congested Conjunctiva, Relative Bradycardia, Number of mosquito bite, Mosquito bleeding place and population. This approach is two parts, and includes a number of techniques, based on a reliable policy framework and process mechanism. They have developed the decision tree and help identify the dengue. This approach is a strategic plan to reduce the risk of dengue fever in the context of a country [11].

2.3 Current methods for plasma leakage detection

Hemoconcentration

Clinically, it is difficult to identify the plasma leakage at present, until the DHF develops. Depending on the haemo-concentrations, the most common way to observe leak is to determine the extent of Hematocrit (HCT) measurements by monitoring the leakage. In excess of 20% of the original value is considered significant leak. However, this method can be more sensitive. Especially when a person's fluid metabolism is monitored, it is very rarely a person's basic value. [2]

Chest X-Ray

Chest X-ray is recommended to increase the sensitivity of detecting pleural effusion. Pleural effusion detected clinically may not be obvious in a chest X-ray (CXR)-PA, but may be seen only in a CXR right lateral decubitus film [2].

2.4 Summary

It is evidence that there is no efficient Decision Support System in Sri Lanka based to detect the critical phase based on the vital signs and blood profiles.

This research will be carried out to solve the above problem using cased-based reasoning to develop web-based solution to support decision making system to early detection dengue phase and do proper clinical management to reduce the death of the dengue patients.

Chapter 3

Technology Adopted

3.1 Introduction

Chapter 2 presented that how the cased-based reasoning can be used to identify dengue phase. This chapter discussed the technologies that can be used to develop web-based solution to early detection of Dengue severity.

3.2 Cased Based Reasoning

Case-based reasoning is a general paradigm for reasoning from experience. It assumes a memory model for representing past events, indexing and organizing them. It is a process for the re-acquisition and modernization of old cases. Settlement of new issues will be dealt with by prior codification of the CBR
Successful solutions to similar issues. [12]

CBR working cycle can be described best in terms of four processing stages: [12]

1. Case retrieval: after the problem situation has been assessed, the best matching case is searched in the case base and an approximate solution is retrieved.
2. Case adaptation: the retrieved solution is adapted to fit better the new problem.
3. Solution evaluation: the adapted solution can be evaluated either *before* the solution is applied to the problem or *after* the solution has been applied. In any case, if the accomplished result is not satisfactory, the retrieved solution must be adapted again or more cases should be retrieved.
4. Case-base updating: If the solution was verified as correct, the new case may be added to the case base.

The CBR process can be defined as a cyclic procedure. The problem has posed a new issue that needs to be addressed in the space. In the first step, by comparing similar problems by reviewing, a new problem can match the previous issues, and the more similar problem and the solution stored there can be found. If the proposed solution meets the need for a new problem situation, the next step is adaptation, occurrence and a new solution. A valid solution within a learning step and a new problem build up a new case. Thus, the CBR system becomes a better argument. As the potential of the system has been enhanced by expanding storage experience. [13]

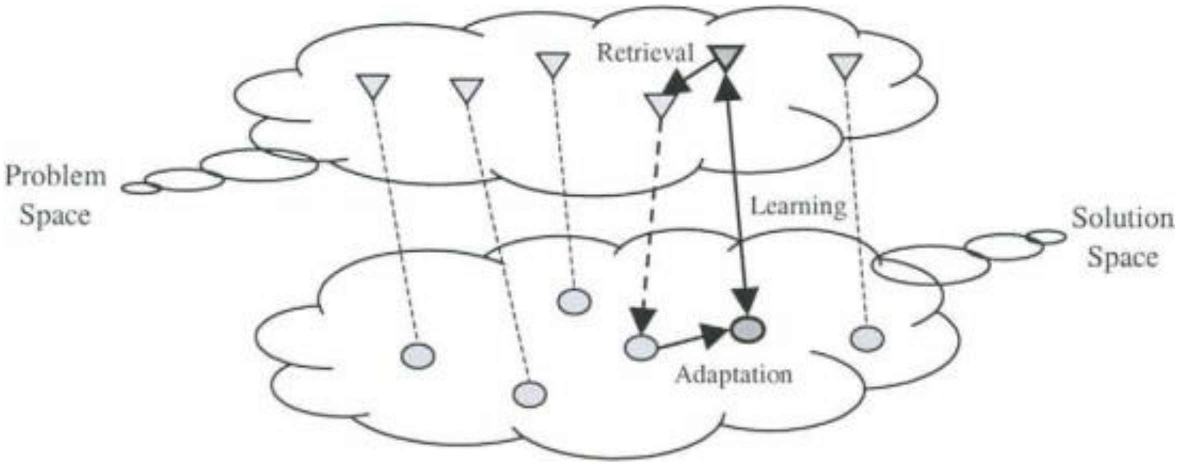

Figure 3-1 - CBR Process

3.3 C#

C # is designed by Microsoft and all of them are used in summary. It is designed to create desktop apps, and more recently for Windows 8/10 apps. It is also part of .NET and is used in languages such as web development and languages such as ASP.

The main advantage of C # is that it runs on CLR. Specifically, with writable components in other languages, it is easy to combine with CLR-compatible languages and many of Microsoft's proprietary features. Note that most of the .NET standards are standardized, which means that it can run on other platforms.

3.4 .NET Framework

.Net Framework is the software framework developed by Microsoft that runs on primarily on windows and recently announced that .Net core can runs on Mac and Linux other than Windows. .NET framework is language independent.

3.5 .NET Web API

ASP.NET Web API is a framework for building web APIs on top of the .NET Framework. Web API is a framework for building HTTP services that can be consumed by a broad range of clients including browsers, mobiles, iPhone and tablets almost same as web services. The web API is usually done as HTTP / REST, nothing defined, output can be e.g. JSON/XML, input can be XML/JSON/or plain data.

An API interacts with other software to accurately define methods for one software to interact. When a data connection is sent over the web, the Web service comes in the picture. The API usually performs call services in a software application. Web applications are using API websites.

3.6 ASP.NET MVC

The ASP.NET MVC is a web application framework developed by Microsoft, which implements the model–view–controller (MVC) pattern. It is open-source software.

On the server side, ASP.NET MVC serves the HTML. ASP.NET Web API handles all requests that relate to the getting, creating, updating and deleting. The client exchanges data with Web API in JSON format.

3.7 Microsoft SQL Server Database

Microsoft SQL Server is a relational database management system developed by Microsoft as a database server, which is a software product with the primary function of storing and retrieving data, requested by other software applications that may be on the same computer or on other computers, on the same computer or other computer.

3.8 Entity Framework

Entity Framework is an Object Relational Mapper (ORM), a tool to simplify mapping between tables in your software, tables and columns in the relative database.

Enhancing the excess work of the application processing data by increasing the productivity of the Entity Framework. The synthesis framework has a more detailed map template, and you can customize the map, for example, by mapping one unit to multiple single-table aliases or multiple units in a single table. The synthesis of the LINQ engine by the engine generates SQL commands. It remembers the changes in objects for remembering.

3.9 Summary

This chapter described about the core technologies used in this research project. Next chapter will discuss the way of using these technologies to build a Decision Support System for Dengue Management.

Chapter 4

A Novel Approach to managing Dengue

4.1 Introduction

Chapter 3 discussed the technologies to develop the tool to manage Dengue in Sri Lanka. This chapter presents the approach to develop the tool manage Dengue using Cased Based Reasoning under several headings problem, Input to the system, Output of the system, process convert input to the output, users of the system and features of the system.

4.2 Problem

Currently there is an issue of unavailability proper mechanism to find out Critical phase of Dengue whether it is leaking or not and how to handle the situation of dengue. This can be solved by the Decision Support System for Dengue Management.

4.3 Cases

Cases are the basic of CBR systems. CBR is heavily dependent on the structure and content of the cases. Initial Cases are obtained from the acquisitions of knowledge by conducting an interview with physician and gathering references from books.

4.4 Input

Doctors can register the patient to the system using patient interface and insert patient details and vital signs and blood profiles using vital sign interface. Vital signs interface includes pulse, Blood Pressure, Pulse Pressure, Resp Rate, Platelet Count, White Cell Count, Fluid intake, urine output and capillary refilling time.

4.5 Output

The output of the system would be the patient information, stage of the Dengue (eg: DF, Early DHF, Critical Stage) and suggestions by analyzing the Vital Signs and graphs of Platelet Count, WCC, Urine Output, PCV, PP. Those graphs and suggestions assistance doctors to easily diagnosis the patients and proper clinical management.

4.5 Process and Features

Cases and rules are obtained from the acquisitions of knowledge by conducting an interview with physician and gathering references from books. Cased based logic is implemented is implemented inside the system.

Doctor register the patient to the system. After that vital signs and blood profiles are entered as input to the system. Then the dengue stage of the patient and suggestion and graphs are displayed as output of the system.

4.6 Users

This tool will be a vital tool to all Doctors and clinical practitioners in order to further strengthen clinical management. are the users. The patients are getting indirect advantage from this.

4.7 Summary

This chapter highlights how the novel approach offers a system to manage Dengue in the process of decision making.

Chapter 5

Design of the Dengue Management Tool

5.1 Introduction

The previous chapter gave a full picture of the entire solution. This chapter describes the design of a solution for the process presented in the approach. We design the solution as a client-server system with a backend database. .NET web API and MVC were used to build the communication between the server and the client. Here we describe the top-level architecture of the design by elaborating on the role of each component of the architecture.

5.2 Top Level Architecture (Design) of Dengue Management Tool

In the designing of the Dengue Management tool, a separate interface module is maintained so that enable access from different sources of inputs. The database is included for data manipulation. The top-level architecture of the Dengue Management tool is shown in Figure 5.1.

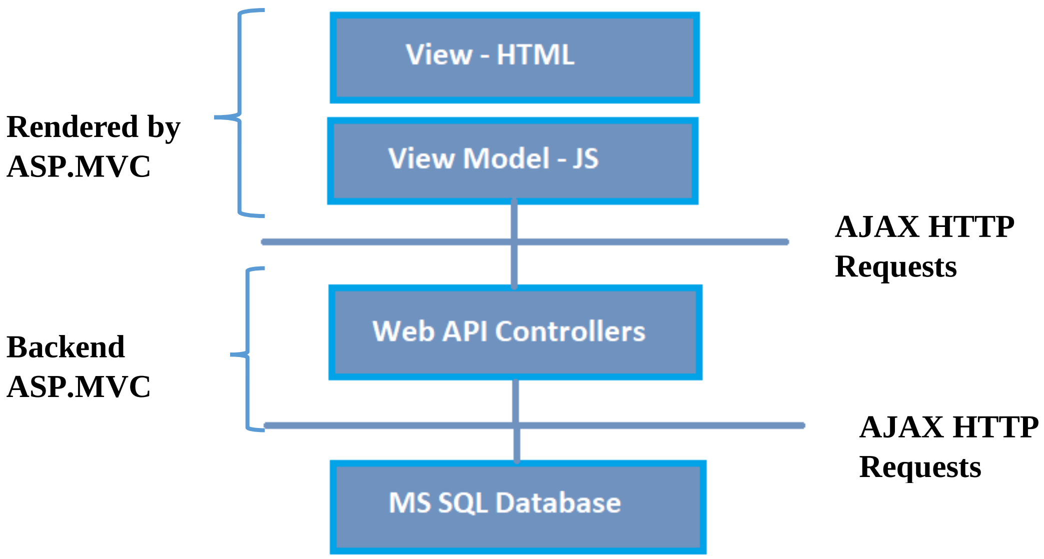

Figure 5.1 – Top-Level Architecture

5.3 User Interface Module

This module enables user interaction with the system based on the input and output requirements. More importantly, this module has direct access to the main back-end database and Analytical Engine. This module is not limited to handle input/output, but execute certain pre-processing on input data and also processing of results to appear the suggestions. Architecture of the web client application is shown in the below diagram.

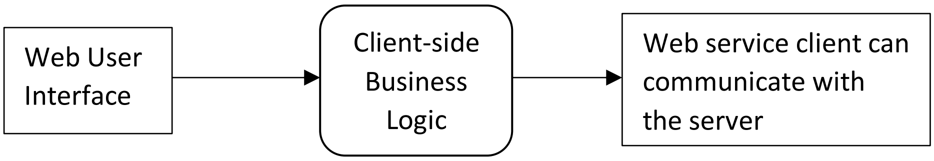

Figure 5.2 - Architecture of Client application

5.4 Analytic Module

This module works as Cased Based Reasoning process, analyze the inputs with the previous data and pushed data to database and display suggestions and current phase of Dengue.

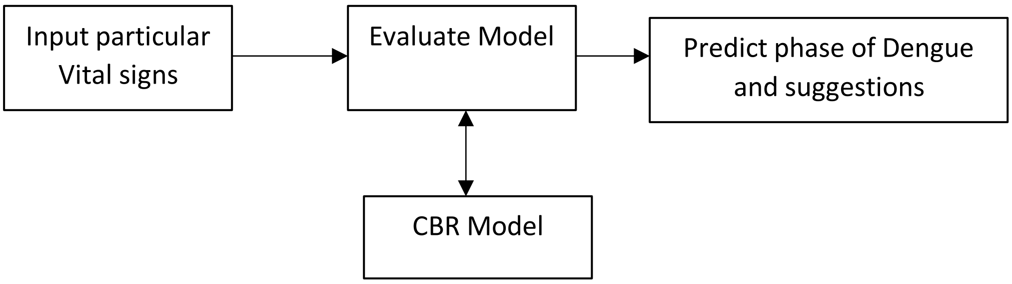

Figure 5.3 - Design of Analytical Module

The initial module is retrieved by using a practical scenario by consulting doctors. This module is consisting of cases and rules for each and every case. Reuse the cases to solve the problem with the known dataset. Cases and rules are revised if necessary and retrain the new module as part of a new case(s) or rule(s). Figure 5.5-2 describes the process of module designing.

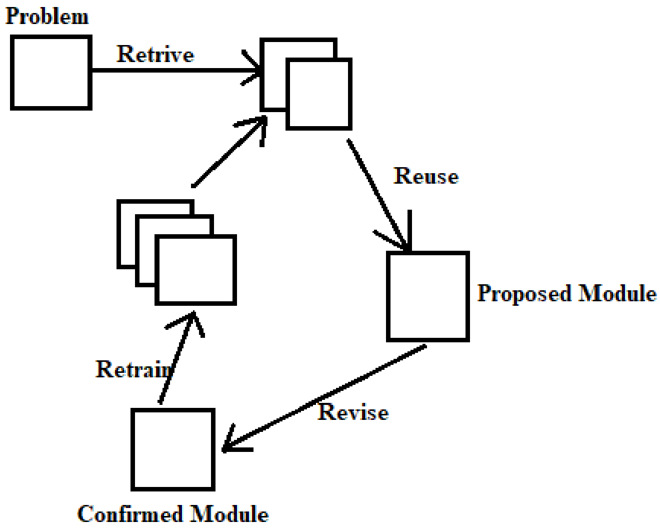

Figure 5.4- CBR Process

5.5 Dengue Phases classification

With the guidance of the Doctors, Dengue phases are classified as below for this research.

- Dengue Fever
- Early DHF
- Possible leaking Or Critical stage
- Critical (Leaking) phase
- Bleeding Phase
- Possibly Recovering

Sub phases of Critical stage

5.6 Back end Database

Database consists of all the patients' information, vital signs information related to each and every patient as below image.

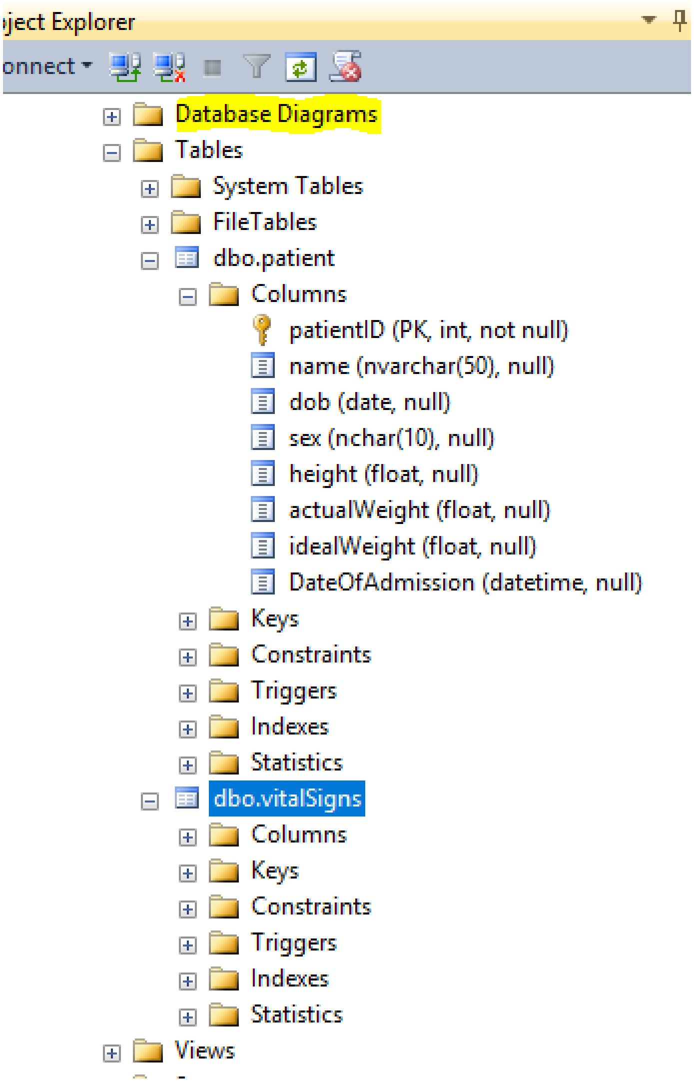

Figure 5.5 - MSSQL Database

5.7 Summary

This chapter provides details on research and applicability of selected research the research. Furthermore, this chapter focused on top level design and CBR design process also described in detail. The main level components of the systems also illustrated in the top-level design diagram. The components that will be interconnected together and how the system is built, is explained in Chapter 6.

Chapter 6

Overall Implementation of the Dengue Management Tool

6.1 Introduction

In chapter 5 the design of the solution has been described in term of what each component does. This chapter will expose the implementation details of each internal module introduced on the previous chapter.

6.2 Overall Implementation

Overall solution is a web based one and has been implemented as .Net based application running on any web browser. The implementation is concerned about ASP.net MVC architecture with Web UI. Web UI module develops based on .Net technology and backend data module is developed by using Entity Framework with MS SQL RDBMS technology for creating databases.

6.3 Data Collection

The records of dengue patients obtained from Centre for the Clinical Management of Dengue and Dengue Haemorrhagic Fever at District General Hospital, Negombo. Each data set consisted of heart rate, systolic and diastolic blood pressures, pulse pressure, respiratory rate, HCT, platelet count, WCC, Urine Output and Fluid Intake at each hour. These values were recorded as numeric values. The selected patients included both males and females between 18 to 60 years of age and weighted over 50 kg. These measurements were taken at equally spaced time points (hourly) since the patient was admitted to the hospital. Here we mainly considered the Dengue patients whose NS1 antigen is positive.

Initially, the manually recorded data Dengue patients were stored in a spread sheet. The most important part of data was preparation to determine the best parameters that contribute to the decision-making. The data selection requires some detailed knowledge of the problem and the underlying data. The most sensitive parameters that contribute to the detection of Critical phase are,

- Pulse pressure (mmHg)
- Packed Cell Volume (PCV) (%)
- Platelet count (x103/uL)
- Urine Output (UOP) (ml/kg/hr)
- White Cell Count(x103/uL)

A	B	C	D	E	F	G	H	I	J	K	L	M	N
	64992				50KG	M					48h		
	OBSERVATION CHART						FLUID BALANCE CHART						
	Date/Time	Pulse	Blood Pre	Pulse pre	Resp.R	PCV	Oral in	IV in	Total in	UOP	Total	platelet	
26/9/2013	3PM	71	120/76	44	22	49		70	280	100		12	
	4PM	64	114/84	30	33	54		70	350	35		10	
	5PM	61	126/85	41	19	54		70	420	30		10	
	6PM	65	129/87	42	17	54		100	520	40		10	
	7PM	67	108/85	23	15	54		100	620	25		10	
	8PM	66	108/78	30	17	54		100	720	40		10	
	9PM	66	103/68	35	20	52		70	790	70		10	
	10PM	63	117/89	28	19	50		100	890	30		12	
	11PM	62	116/85	31	20	50		100	990	30		12	
	12PM	61	110/83	27	22	50		100	1090	30		12	
27/9/2013	1AM	63	92/58	34	18	50		100	1190	28		12	
	2AM	58	116/82	34		49		100	1290	30		12	
	3AM	59	111/83	28	24	49		100	1390	30		12	
	4AM	60	120/79	41	24	48		100	1490	30		11	
	5AM	60	110/81	29	22	48		80	1570	40		11	
	6AM	63	120/83	37	22	48		80	1650	70		5	
	7AM	62	115/62	53	14	48		80	80	65		5	
	8AM	54	120/79	41	24	48		80	160	35		5	
	9AM	51	133/92	41	21	48		80	240	30		5	

Sheet1 | Sheet2 | Sheet3 | Sheet4 | Sheet5 | Sheet6 | Sheet7 | Sheet8 | Sheet9 | Sheet10 | Sheet5## | Sheet6##

Figure 6.1- Sample of collected data

6.4 Implementation of Back-end data Module

Database of this application has been implemented with MS SQL database technology. Database stores all the of patients' information, vital signs information related to each and every patient.

The patient table consists of below fields.

- PatientID – This is the primary key of the table
- Name – Name of the patient
- Dob – Date of birth. This is used to calculate the age of the patient
- Sex – Female or Male
- Height – Height of the patient

- Actual weight – Actual body weight of the patient
- Ideal weight – Ideal body weight of the patient. Ideal body weight is calculated by considering the Height of the patient and Gender of the patient. Below chart is used to calculate the Ideal body weight.

Adults Weight to Height Ratio Chart		
Height - Ft. In. (cms)	Female	Male
4' 6" - (137 cm)	63 - 77 lb - (28.5 - 34.9 kg)	63 - 77 lb - (28.5 - 34.9 kg)
4' 7" - (140 cm)	68 - 83 lb - (30.8 - 37.6 kg)	68 - 84 lb - (30.8 - 38.1 kg)
4' 8" - (142 cm)	72 - 88 lb - (32.6 - 39.9 kg)	74 - 90 lb - (33.5 - 40.8 kg)
4' 9" - (145 cm)	77 - 94 lb - (34.9 - 42.6 kg)	79 - 97 lb - (35.8 - 43.9 kg)
4' 10" - (147 cm)	81 - 99 lb - (36.4 - 44.9 kg)	85 - 103 lb - (38.5 - 46.7 kg)
4' 11" - (150 cm)	86 - 105 lb - (39 - 47.6 kg)	90 - 110 lb - (40.8 - 49.9 kg)
5' 0" - (152 cm)	90 - 110 lb - (40.8 - 49.9 kg)	95 - 117 lb - (43.1 - 53 kg)
5' 1" - (155 cm)	95 - 116 lb - (43.1 - 52.6 kg)	101 - 123 lb - (45.8 - 55.8 kg)
5' 2" - (157 cm)	99 - 121 lb - (44.9 - 54.9 kg)	106 - 130 lb - (48.1 - 58.9 kg)
5' 3" - (160 cm)	104 - 127 lb - (47.2 - 57.6 kg)	112 - 136 lb - (50.8 - 61.6 kg)
5' 4" - (163 cm)	108 - 132 lb - (49 - 59.9 kg)	117 - 143 lb - (53 - 64.8 kg)
5' 5" - (165 cm)	113 - 138 lb - (51.2 - 62.6 kg)	122 - 150 lb - (55.3 - 68 kg)
5' 6" - (168 cm)	117 - 143 lb - (53 - 64.8 kg)	128 - 156 lb - (58 - 70.7 kg)
5' 7" - (170 cm)	122 - 149 lb - (55.3 - 67.6 kg)	133 - 163 lb - (60.3 - 73.9 kg)
5' 8" - (173 cm)	126 - 154 lb - (57.1 - 69.8 kg)	139 - 169 lb - (63 - 76.6 kg)
5' 9" - (175 cm)	131 - 160 lb - (59.4 - 72.6 kg)	144 - 176 lb - (65.3 - 79.8 kg)
5' 10" - (178 cm)	135 - 165 lb - (61.2 - 74.8 kg)	149 - 183 lb - (67.6 - 83 kg)
5' 11" - (180 cm)	140 - 171 lb - (63.5 - 77.5 kg)	155 - 189 lb - (70.3 - 85.7 kg)
6' 0" - (183 cm)	144 - 176 lb - (65.3 - 79.8 kg)	160 - 196 lb - (72.6 - 88.9 kg)
6' 1" - (185 cm)	149 - 182 lb - (67.6 - 82.5 kg)	166 - 202 lb - (75.3 - 91.6 kg)
6' 2" - (188 cm)	153 - 187 lb - (69.4 - 84.8 kg)	171 - 209 lb - (77.5 - 94.8 kg)
6' 3" - (191 cm)	158 - 193 lb - (71.6 - 87.5 kg)	176 - 216 lb - (79.8 - 98 kg)
6' 4" - (193 cm)	162 - 198 lb - (73.5 - 89.8 kg)	182 - 222 lb - (82.5 - 100.6 kg)
6' 5" - (195 cm)	167 - 204 lb - (75.7 - 92.5 kg)	187 - 229 lb - (84.8 - 103.8 kg)

Figure 6.2 - Ideal Body Weight *[14]*

VitalSigns table consists of below fields.

- Id – This is the primary key of the table
- patientID – This is the foreign key of the table and this is refereeing the patientID of the patient table.
- Pulse – Pulse rate (/min)
- Systolic – The amount of Systolic pressure. (mmHg)
- Diastolic - The amount of Systolic pressure. (mmHg)
- Pp – Pulse pressure. This is calculated by subtracting value of Diastolic from the value of Systolic. (mmHg)

- Pcv – Packed cell volume. This is called as Haematocrit (HCT) (%) .
- Wcc – White Cell Count
- Plt – Platelet Count (x10^3/uL)
- urineOutput – Urine Output (ml/kg/hr)
- fluidIntake – amount of total fluid intake (ml/kg/hr)
- hours – Number of hours of the patient from the hospitalized time
- bodyTemp – Body temperature (Celsius) at each hour
- respiratoryRate – Respiratory rate at each hour
- oralIn – Oral fluid intake at each hour
- IVin – Amount of IV fluid at each hour
- capilaryRefilling – Capillary Refilling time
- IVType – Type of IV fluid whether it is normal saline, full bolus, half bolus of Dextran
- criticalHour – If the patient is on or was in critical phase, number of hours n critical phase. When the WCC is decreasing and next increasing with the decreasing of platelet count, this is the startup point of the critical phase.

This module was implemented by using Entity Framework which is very easy to use with MS SQL database and easy to maintain. A snapshot of main database diagram appears in Appendix A.

6.5 Implementation of The Server Side

Server side is developed by using ASP.NET web API. The controller handles the HTTP requests. And controller act as serving pages to the website when necessary. From java script code sends the JSON request to the server and server handles those requests to update, add and get patient details and vital signs details.

6.6 Implementation of Analytic Model

Analytic Module is the major part of this research. This Model is developed by using Cases Based Reasoning process. Initial module is retrieved by using practical scenario by consulting doctors. This module is consisting of cases and rules for each and every case. Reuse the cases to solve the problem with the known dataset.

Cases and rules are revised if necessary and retrain the new module as part of new case(s) or rule(s). Below are the created cases and rules.

Case	Rules
1. Dengue Fever Phase	• WCC is decreasing • Platelets count is not decreasing than 150,000
2. Early DHF Phase	• Platelet count is decreasing but above 100,000 • White Cell count is decreasing
3. Possible of leaking Phase or the critical stage	• Platelet count is less than 100,000 • White Cell Count (WCC) is increasing after decreasing
4. Critical Phase (Leaking Phase)	• Platelet count is decreasing than 100,000 or maintaining below 100,000 • White Cell Count (WCC) is increasing • Pulse pressure is less than 30 • Increasing the PCV • UO is decreasing • Capillary refilling time is more than 2 seconds
5. Bleeding Phase	• Pulse pressure is decreasing • PCV is decreasing (20%) or static (in the period of PCV should increase) • Capillary refilling time is decreasing • Urine Output is decreasing

6. Recovery Phase	• Platelet count is increasing by 5000 • Urine Output is increasing • Stabilization of PCV

Table 6.1- Generated cases and rules

6.7 Implementation of Client Side

Mainly user interface module is developed by using ASP.Net MVC technology which is latest web technology introduced by Microsoft. All frontend developments are done by using JQuery, Ajax, Java script for all client-side scripting.

At beginning user can see below screenshot of UI with the list of patients, option for the adding patient to the system and suggestions section with the status of Dengue.

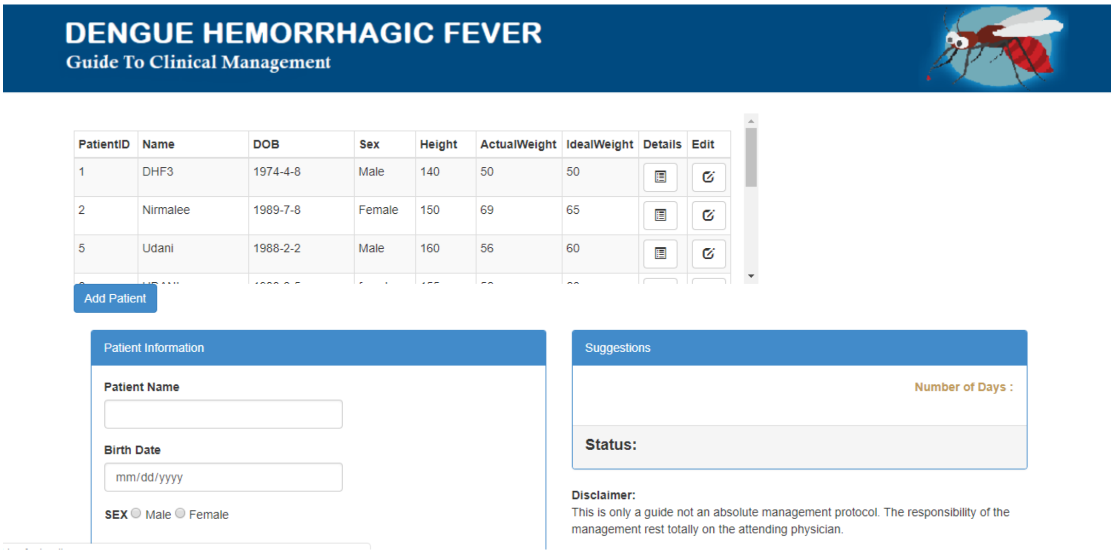

Figure 6.3 - Screenshot of main Interface

When the user is clicked on the details button of the selected employee, user can see the details of the patient and suggestions to the patient and status of the patient as below screenshot.

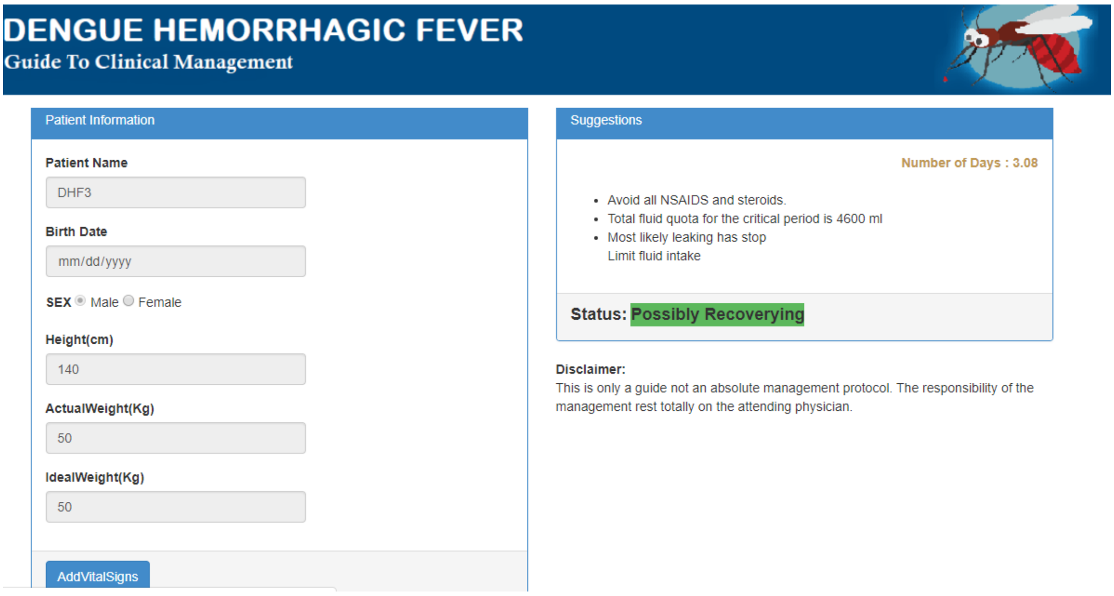

Figure 6.4 - Screenshot of selected patient

Here suggestion for the total fluid quota for the critical phase is calculated with the below equation.

Total Fluid Quota = 100 ml/kg for first 10kg +

50 ml/kg for next 10kg +

20 ml/kg for balance weight +

50 ml * body weight (kg)

Note: Here actual body weight is taken for the calculation if it is lower than the Ideal Body Weight. And the maximum weight for the total fluid quota is calculated in any patient should not exceed 50kg.

In addition, the user can see the below graphs which ae related the selected patient. There are developed by using Razor graphs and chart.js. The graphs are drawn for the most important selected parameters for the consultant.

1. Pulse Pressure variation graph
   X-Axis: Number of Hours
   Y-Axis: Pulse pressure (mmHg)

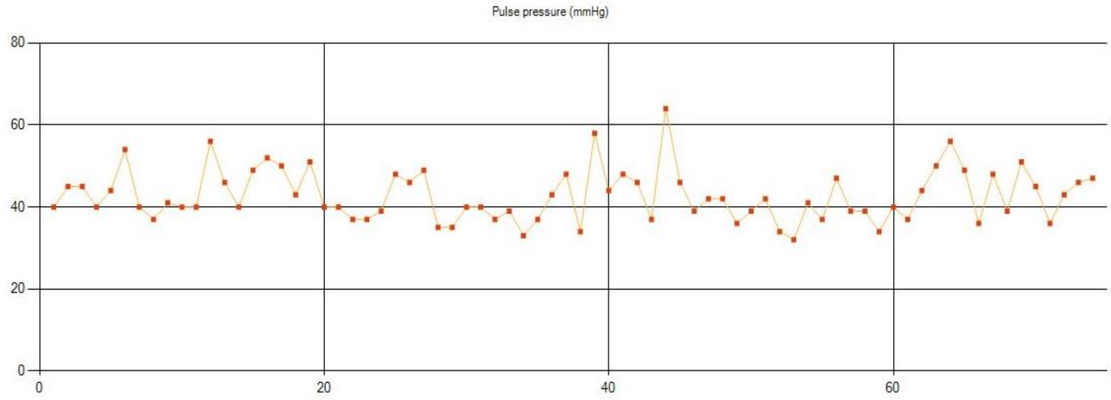

Figure 6.5 - Pulse Pressure

2. Platelet Count variation Graph

   X-Axis: Number of Hours

   Y-Axis: Platelet count (x103/uL)

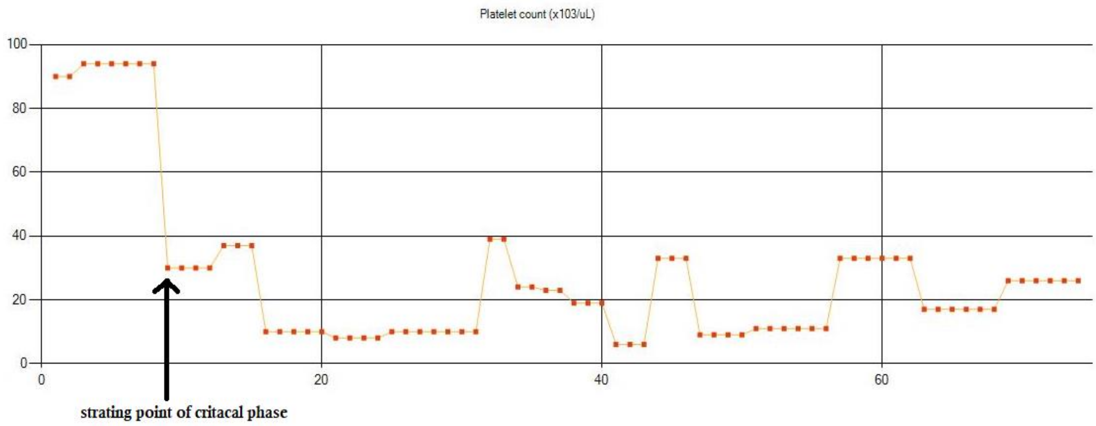

Figure 6.6 - Platelet Count

3. Packed Cell Volume Variation Graph

   X-Axis: Number of Hours

   Y-Axis: Packed Cell Volume (PCV) (%)

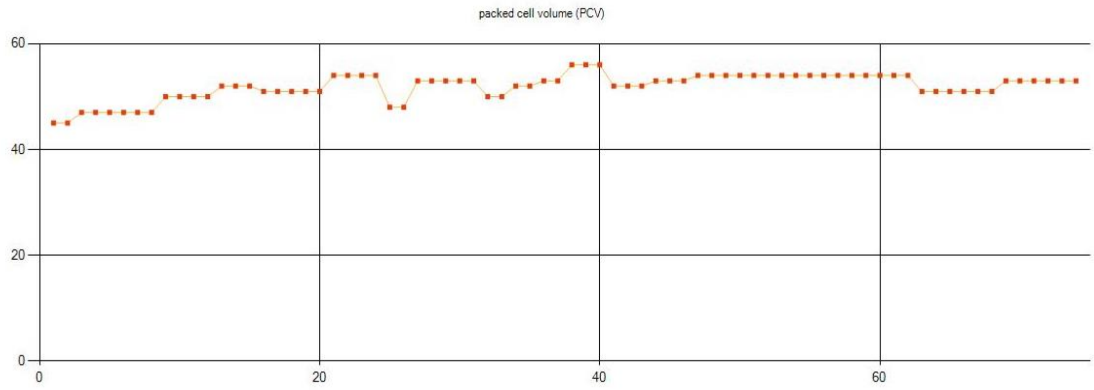

Figure 6.7- Packed Cell Volume

4. White Cell Count Variation Graph.

   X-Axis: Number of Hours

   Y-Axis: White Cell Count(x103/uL)

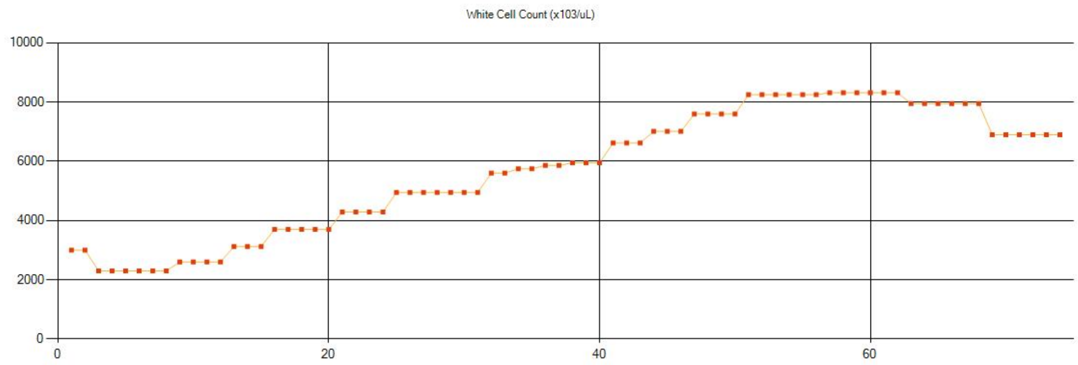

Figure 6.8 - White Cell Count

5. Total Fluid Quota Graph

   X-Axis: Number of Hours

   Y-Axis: Remaining fluid Quota and used fluid Quota (ml/kg/hr)

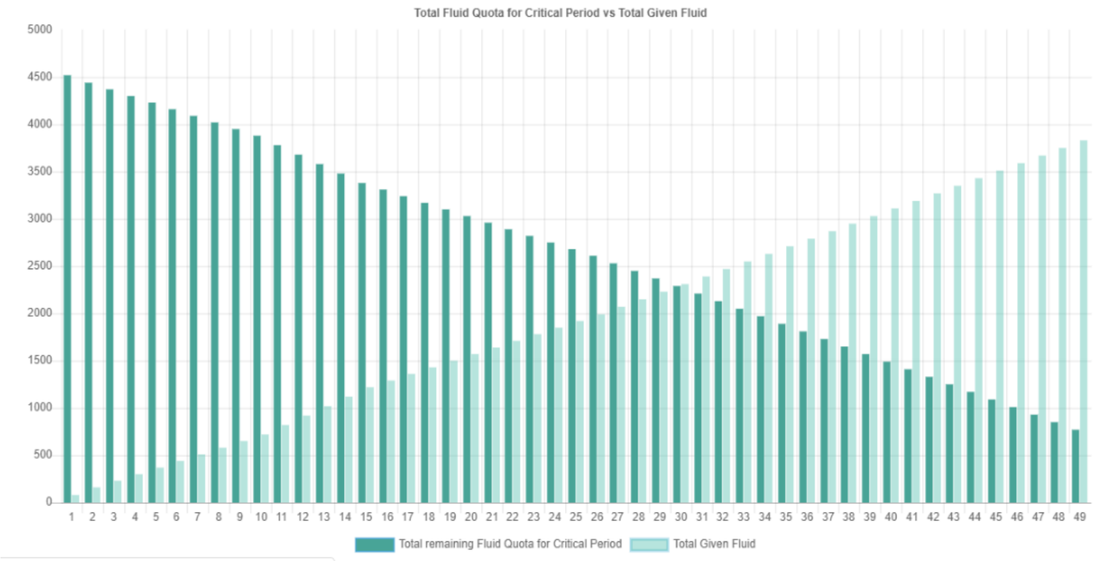

Figure 6.9 - Remaining fluid vs used fluid quota

In the “Suggestions” section, suggestion and status of the patient is displayed. For this Cased based reasoning analytic model is in client side. That is written by using JavaScript.

Following code segment present the implementation of the cased based reasoning analytic model.

```
function vitalSignsListSuccess(vitalSigns, patient) {
    //get last record of vital sign
    var vitalSign = vitalSigns[vitalSigns.length - 1];
    var vitalSign2 = null; //get last record - 1 of vital sign
    var initVitalSign = vitalSigns[0]; //inital vital signs
    var vitalSign3 = null; //get last record - 2 of vital sign

    if (vitalSigns.length > 1)
    {
        vitalSign2 = vitalSigns[vitalSigns.length - 2];//last - 1
        riseOfPcv = ((vitalSign.pcv - initVitalSign.pcv) / initVitalSign.pcv)
                     * 100; //percentage of PCV increment
        if ((vitalSign2.plt > vitalSign.plt) &&
           (vitalSign2.pcv > vitalSign.pcv) &&//decreasing PLT & decreasing PCV
           (vitalSign2.pp > vitalSign.pp) && //decreasing pp
           (vitalSign2.urineOutput > vitalSign.urineOutput)) //decreasing uo
        {
            //POSSIBLE BLEEDING PHASE
            $("#severity").append("<label class=\"label-danger\"
              style=\"font-size:large;font-weight:bold\">" +
              "Possible Bleeding Phase" + "</label>");
            $("#suggestion1 ul").append("<li>" +
              "He/She may be bleeding." + "</li>");
        }
        else if ((vitalSign2.wcc > vitalSign.wcc) &&
            (vitalSign2.plt > vitalSign.plt && vitalSign.plt > 150))
```

```
{
    //if decreasing WCC & decreasing PLT & PLT>150, belongs to DENGUE
    FEVER PHASE
    $("#severity").append("<label class=\"label-warning\"
      style=\"font-size:large;font-weight:bold\">" +
      "Dengue Fever Phase" + "</label>");
    $("#suggestion1 ul").append("<li>" +
      "Decreasing Platelets count & White Cell Count." + "</li>");
}
else if ((vitalSign2.wcc > vitalSign.wcc) &&
              (vitalSign2.plt > vitalSign.plt && vitalSign.plt > 100))
{
   //if decreasing WCC & decreasing PLT & PLT>100, belongs to EARLY
   DHF PHASE
    $("#severity").append("<label class=\"label-warning\"
      style=\"font-size:large;font-weight:bold\">" +
      "Early DHF Phase" + "</label>");
    $("#suggestion1 ul").append("<li>" +
      "Decreasing Platelets count & White Cell Count." + "</li>");
}
else if (vitalSign.plt >= vitalSign2.plt)//increasing plt
{
    if ((vitalSign.plt - vitalSign2.plt) * 1000 >= 5000)
    {
        //If the increasing plt count more than 5000, belongs to
          POSSIBLE RECOVERING phase
        $("#suggestion1 ul").append("<li>" +
            "Most likely leaking has stop" + "<br>" +
            "Limit fluid intake" + "</li>");
        $("#severity").append("<label class=\"label-success\"
            style=\"font-size:large;font-weight:bold\">" +
             "Possibly Recovering " + "</label>");
    }
    else if ((vitalSign.urineOutput > vitalSign2.urineOutput) &&
        (vitalSign.pcv <= vitalSign2.pcv))
    {
        //If the increasing plt count and increasing UO and,belongs to
          POSSIBLE RECOVERING phase
        $("#suggestion1 ul").append("<li>" +
            "Most likely leaking has stop" + "<br>" +
            "Limit fluid intake" + "</li>");
        $("#severity").append("<label class=\"label-success\"
            style=\"font-size:large;font-weight:bold\">" +
            "Possibly Recovering " + "</label>");
    }
    else if (vitalSign.plt = vitalSign2.plt)
        if (vitalSign.plt <= 100)
            decreasingPlt(vitalSigns, patient);
}
else if ((vitalSign.plt <= vitalSign2.plt) &&
             (vitalSign.plt <= 100))
      //Platelet count is decreasing than 100,000 or maintaining below
      100,000
{
    decreasingPlt(vitalSigns, patient);
}
    }
}


function decreasingPlt(vitalSigns, patient) {
```

```
//get last record of vital sign
var vitalSign = vitalSigns[vitalSigns.length - 1];
var vitalSign2 = null;
var initVitalSign = vitalSigns[0];//initial vital signs
var vitalSign3 = null;
vitalSign2 = vitalSigns[vitalSigns.length - 2];//last - 1
$("#suggestion1 ul").append("<li>" +
   "Platelet count is remaining the same below 100,000 or below the
    previous." + "<br>"
    + "Please do ultra sound scan to exclude early phase of leaking." +
    "</li>");
vitalSign3 = vitalSigns[vitalSigns.length - 3];//last - 2
if ((vitalSigns.length >= 3) &&
    (getValue(vitalSigns, vitalSigns.length - 2) <
         getValue(vitalSigns, vitalSigns.length - 3)) &&
    (vitalSign.wcc > getValue(vitalSigns, vitalSigns.length - 2)))
{//wcc decreasing and increasing
    vitalSign3 = vitalSigns[vitalSigns.length - 3];//last - 2
    $("#suggestion1 ul").append("<li>" +
      "WCC has started to increase while the platelet count is remaining
       the same below 100,000 or below the previous one." + "<br>"
        + "Which means that has a chance of leaking in there." + "</li>");
    $("#suggestion1 ul").append("<li>" +
      "From this phase up to 48hours is critical and do close monitoring."
      + "</li>");
    if (vitalSign.pp < 30 &&
        vitalSign.urineOutput < vitalSign2.urineOutput)
    //decreasing UO and pp < 30
    {
        $("#severity").append("<label class=\"label-danger\"
           style=\"font-size:large;font-weight:bold\">" +
           "Critical Phase (Leaking Phase)" + "</label>");
    }
    else {
        $("#severity").append("<label class=\"label-danger\"
           style=\"font-size:large;font-weight:bold\">" +
           "Possible of leaking Phase or the critical stage" + "</label>");
    }
}
else if (vitalSign.wcc >
         getValue(vitalSigns, vitalSigns.length - 2))
//increasing wcc
{
    if (vitalSign.pp < 20)
    {
        $("#severity").append("<label class=\"label-danger\"
           style=\"font-size:large;font-weight:bold\">" +
           "Critical Phase (Leaking Phase)" + "</label>");
        $("#suggestion1 ul").append("<li>" +
           "In critical phase and do close monitoring." + "</li>");
    }
    else if ((vitalSign.pp < 30) &&
        (vitalSign.urineOutput < vitalSign2.urineOutput) &&
        (vitalSign.pcv > gePCVtValue(vitalSigns, vitalSigns.length - 2)))
    {
        // decreasing UO && increasing pcv
        $("#severity").append("<label class=\"label-danger\"
           style=\"font-size:large;font-weight:bold\">" +
           "Critical Phase (Leaking Phase)" + "</label>");
        $("#suggestion1 ul").append("<li>" +
           "In critical phase and do monitoring." + "</li>");
    }
```

```
        else if (vitalSign.pp < vitalSign2.pp)
        //pp decreasing
        {
            $("#suggestion1 ul").append("<li>" +
               "Pulse pressure is decreasing. Consider possibility of leaking.
                Do Ultra Sound scan." + "</li>");
            $("#severity").append("<label class=\"label-danger\"
               style=\"font-size:large;font-weight:bold\">" +
              "Possible of leaking Phase or the critical stage" + "</label>");
        }
    }
    else if (vitalSign.wcc <
                getValue(vitalSigns, vitalSigns.length - 2))//decreasing wcc
    {
        $("#suggestion1 ul").append("<li>" +
           "Decreasing WCC and decreasing Platelet count. Consider possibility
            of leaking. Do Ultra Sound scan." + "</li>");
        $("#severity").append("<label class=\"label-warning\"
           style=\"font-size:large;font-weight:bold\">" +
          "Early DHF Phase" + "</label>");
    }
    else {
        $("#severity").append("<label class=\"label-warning\"
          style=\"font-size:large;font-weight:bold\">" +
         "Early DHF Phase" + "</label>");
    }
}
```

Vital signs of the patient can be inserted from the below “Add Vital Sign” window.

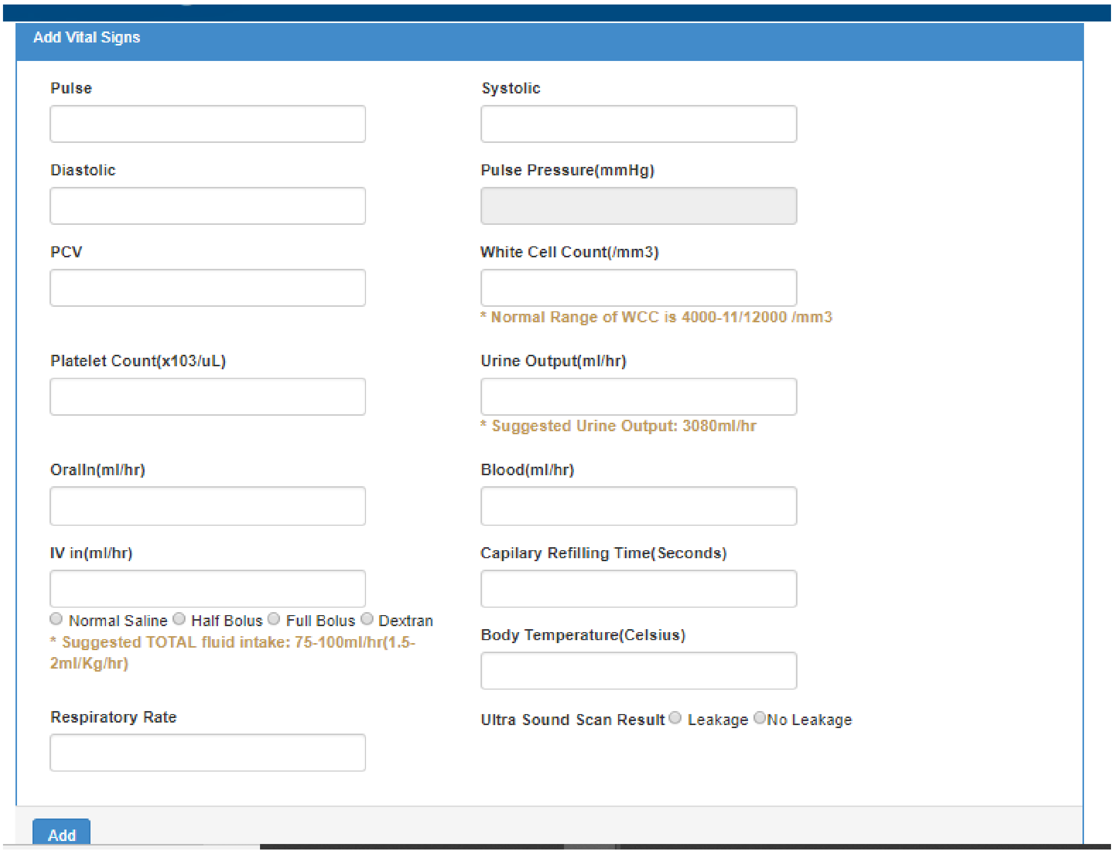

Figure 6.10 - Adding vital Signs window

6.6 Summary

This chapter provided overall implementation details of each module of the proposed solution. Moreover, it mentioned software and cased based reasoning techniques for model development with align to design. Next chapter evaluates the module implemented in the solution.

Chapter 7

Evaluation

7.1 Introduction

The chapter 6 discussed the details on implementation of all the modules mentioned in the proposed solution. This chapter presents how the software solution can be tested with respect to different aspects such as functionality, reliability, efficiency, maintainability and portability.

Testing is a process of evaluating a system and its components with the intent to find whether it satisfies the given requirements. Testing is running a system in order to identify any gaps, errors, bugs or missing requirements with respect to actual requirements.

7.2 Evaluation

For the evaluation of results, set of sample data was inserted into the system database and tested the actual results with expected results. To test the Cased based reasoning process, sample set of vital signs data was gathered from Centre for Clinical Management of Dengue and Dengue Haemorrhagic Fever at District General Hospital, Negombo feed to the system and verified each case with the expected results. Server application was hosted in a localhost and Client and server with the same machine is used to test the user interface stability and to check the outputs were correct.

	Number of Actual vital signs Records	Number of which give expected results
Early DHF Phase	30	30
Possible of leaking Phase or the critical stage	20	15
Critical Phase (Leaking Phase)	15	10
Possible Bleeding Phase	10	5
Possible of Recovery Phase	25	20
	100	80

Table 7.1- Evaluation Chart

Accuracy is 80%.

Following testing methods were used during testing process.

- Unit Testing
- Integration Testing
- Validation Testing
- Systems Testing
- Acceptance Testing

Detailed descriptions of test cases are included in Appendix B.

7.3 Summary of Evaluation

This chapter discussed about the evaluation and the testing aspects of the system according to the aims and objectives defined earlier. Test results were analyzed and bugs were fixed to bring the system into an acceptable level. Next chapter will describe the conclusion of the research project and further work that can be implemented.

Chapter 8

Conclusion and Future Work

8.1 Introduction

This chapter contains a discussion on the result obtain from the research and how the objectives are met. The future works can be done to continue this research for make the broader environment also discussed.

8.2 Conclusion

In Sri Lanka, there doesn't exist any good method to detect the Critical phase of Dengue as early as possible of the patients. Early detection and give proper medical treatment will help to prevent dengue shock or severe involvement and death of people. During the last year also around 600 people have died because of the Dengue. Implementing Dengue Management System will help to identify early stage of Dengue and manage dengue illness without going to DSS. The major contribution of this research is to manage Dengue death in Sri Lanka.

8.3 Future Development

This research is mainly focused on NS1 antigen positive DHF patients. It is better if we can expand this system to DSS stage by identifying more cases and rules with more parameters.

When storing large amount of data in the database, it can be slow. We can improve this by using indexes or any other database related techniques.

And the current developed system doesn't consist of enough validations and also no login for the system. So, system can be improved by applying User experience techniques with logins and validations.

System has developed to as web-based solution and this can be improved as mobile application or web service.

8.4 Summary

This chapter provided a conclusion of overall achievement met through the research project called Decision Management System for Dengue Management and future work and improvements related to the system.

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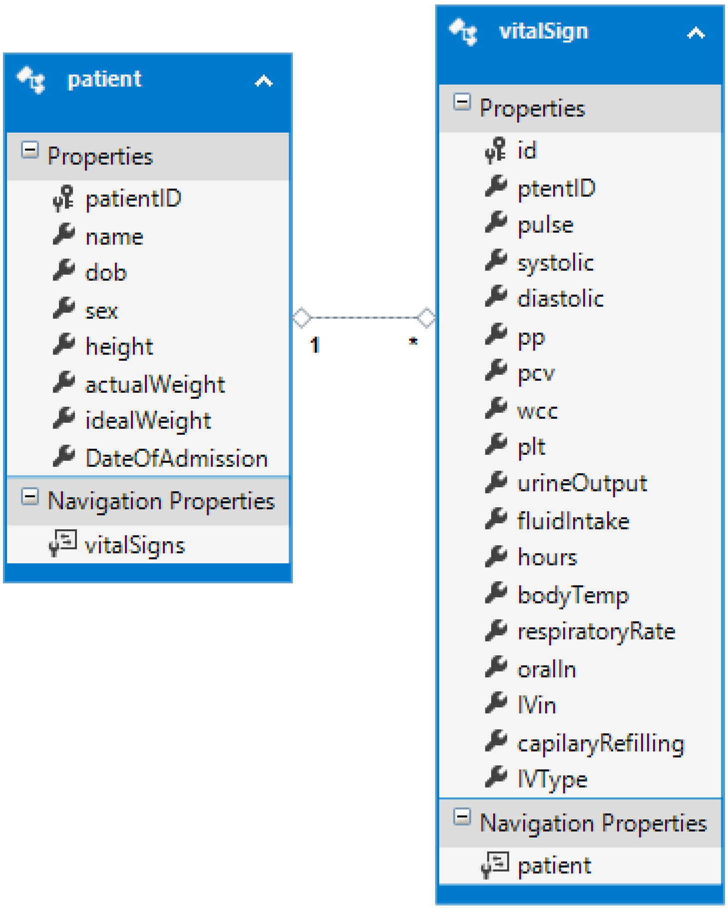
[16] J. E. Jacob, V. Varghese, W. Rose and D. Adhikari, "DENGUE PROTOCOL FOR MANAGEMENT," in *DENGUE - PROTOCOL*, Department of Child Health, Christian Medical College, Vellore, 2015, pp. 40-50.

Appendix A

Backend Data Module Implementations



Appendix A: 1 Backend database diagram

Appendix B

Testing and Evaluation

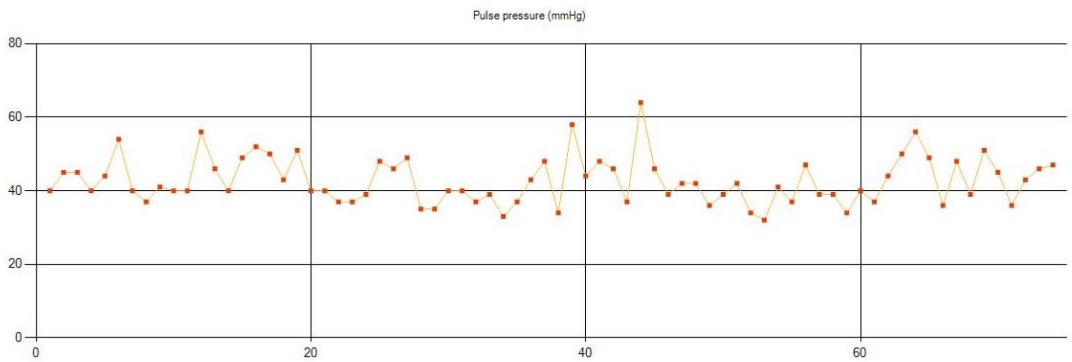
Sample test scenarios as below.

1. All the patients should display in the table in Home page as below image and add patient, edit patient and details of the patient functionalities are working as expected.

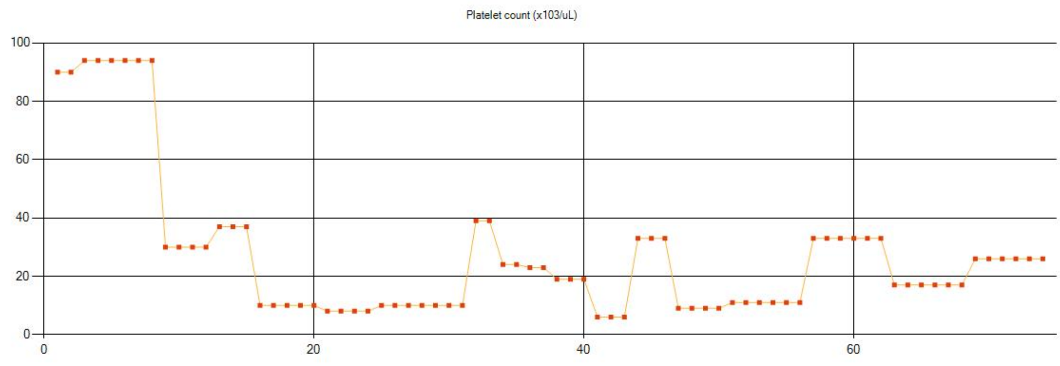
PatientID	Name	DOB	Sex	Height	ActualWeight	IdealWeight	Details	Edit
1	DHF3	1974-4-8	Male	5	50	50		
2	Nirmalee	1989-7-8	Female	5	69	65		
5	Udani	1988-2-2	Male	5	56	60		
6	UDANI	1988-2-5	female	4	56	60		

Appendix B-1- Patient Details

2. When the click on the details of the selected patient, patient details and graphs related to his/her vital signs are displayed in the page as below.



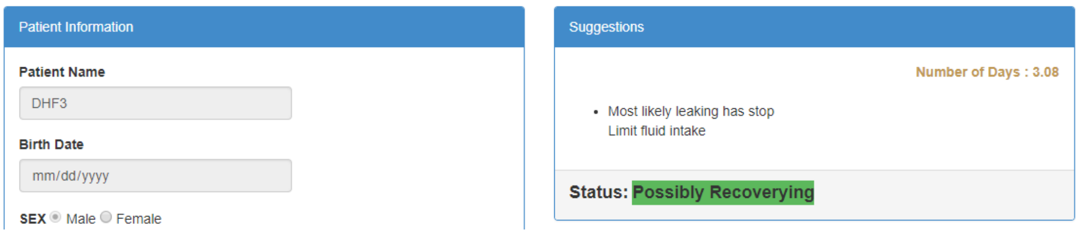
Appendix B-2- Variations of Pulse pressure



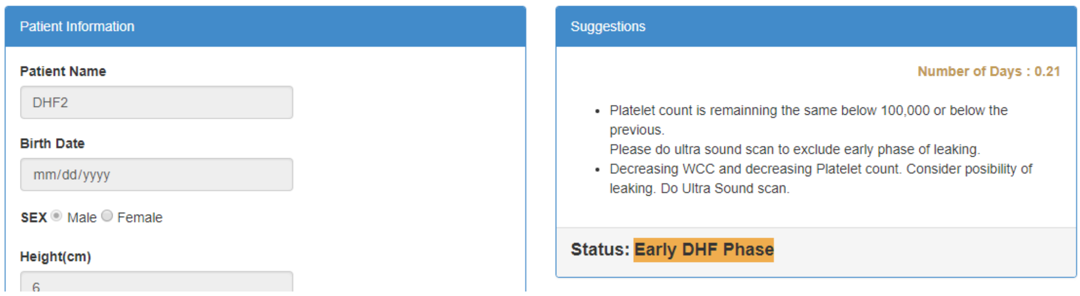
Appendix B-3-Variation of Platelet Count

Like this WCC, Urine Output and PCV graphs also displayed in the system. Those graphs are verified by considering the database values.

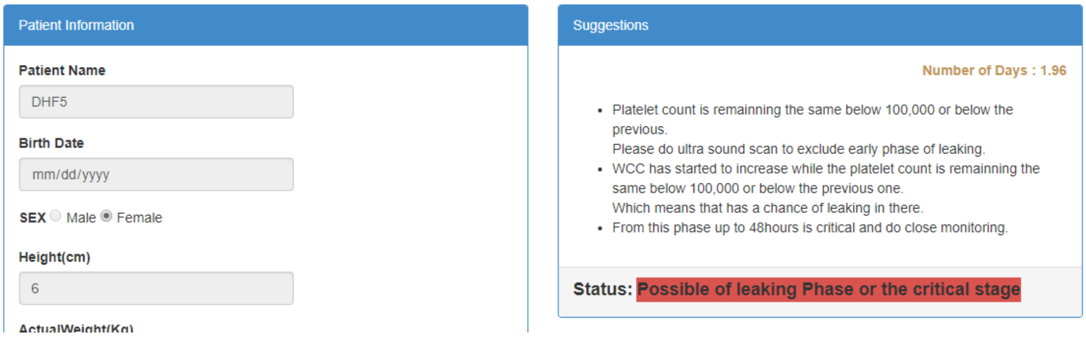
3. When the click on the details of the selected patient, suggestions and current stage of dengue is displayed in the right side as below. Verified those values by comparing the cases and rules.



Appendix B-4-Possibly Recovery Phase of the patient

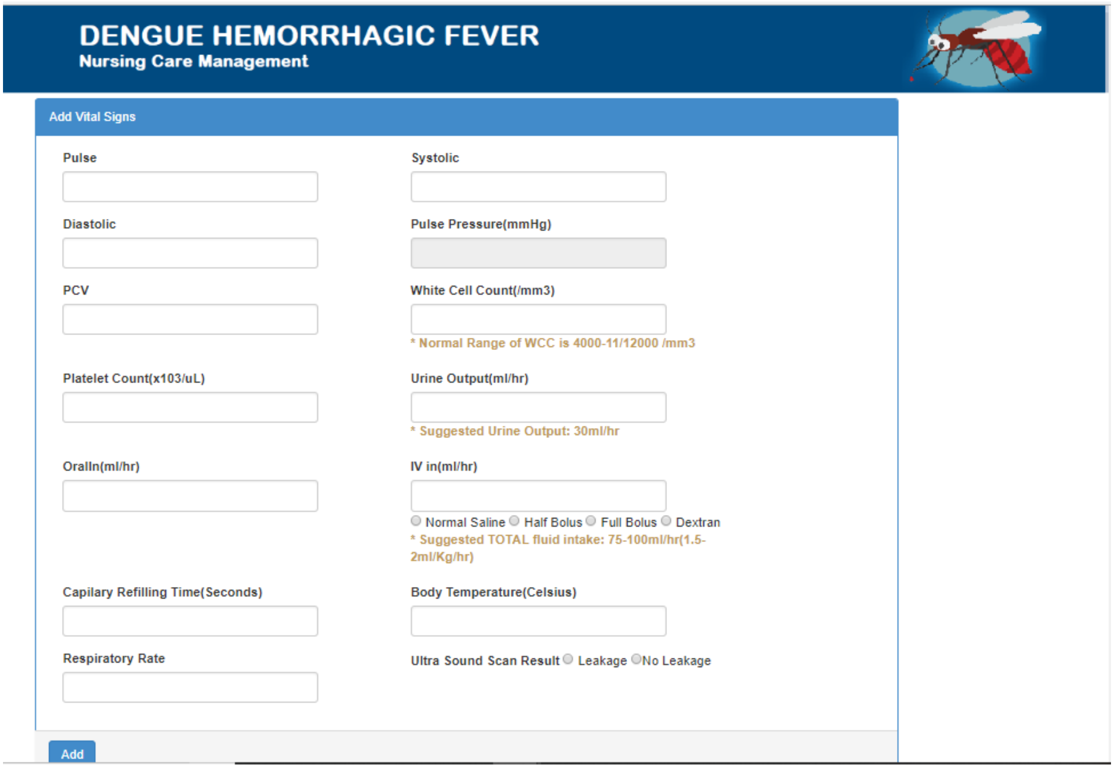


Appendix B-5-Early DHF Phase of the patient



Appendix B-6-Leakage phase of the patient

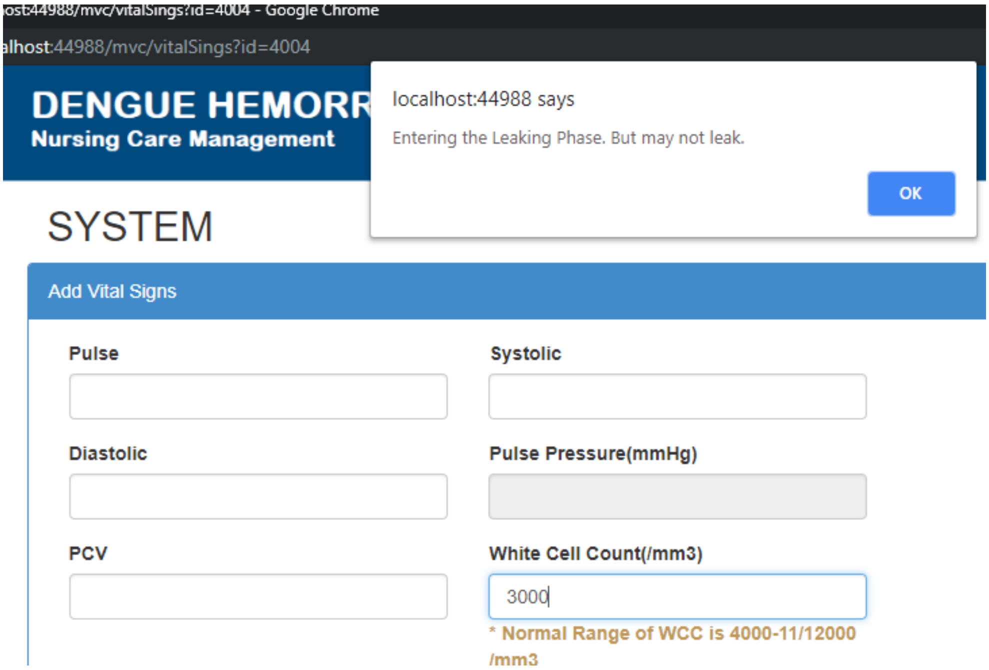
4. Vital sign entering window is verified as below
   - Enter vital signs and save and verified the data are inserted to the database.
   - Vital sign entering window should display with the suggestions of WCC, Fluid Intake and Urine Output as below image.



Appendix B-7-Vital signs entering window

- Vital sign parameters in the system should be validated as below.
  - ✓ White Cell Count

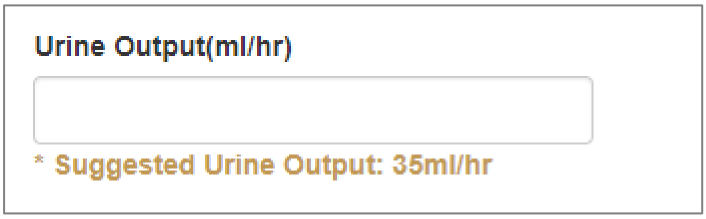
    When the WCC is decreasing and at the starting point of the increasing below popup message should be display.



Appendix B-8-Popup message when entering the Critical Stage

- ✓ Urine Output

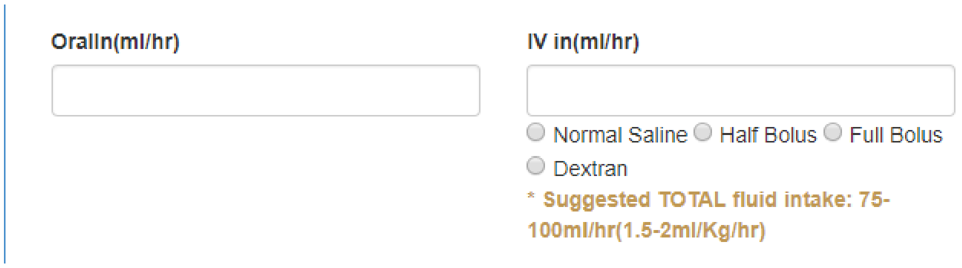
  Urine output should display as suggestion. Normal Urine output should be half of previous Fluid intake.



Appendix B-9-Suggested Urine Output

- ✓ Fluid Intake

  Suggested total fluid intake should be display in the window. It is calculated according to the ideal body weight and actual body weight.



Appendix B-10-Suggested Fluid Intake

- ✓ Pulse Pressure

Pulse pressure should be calculated correctly.

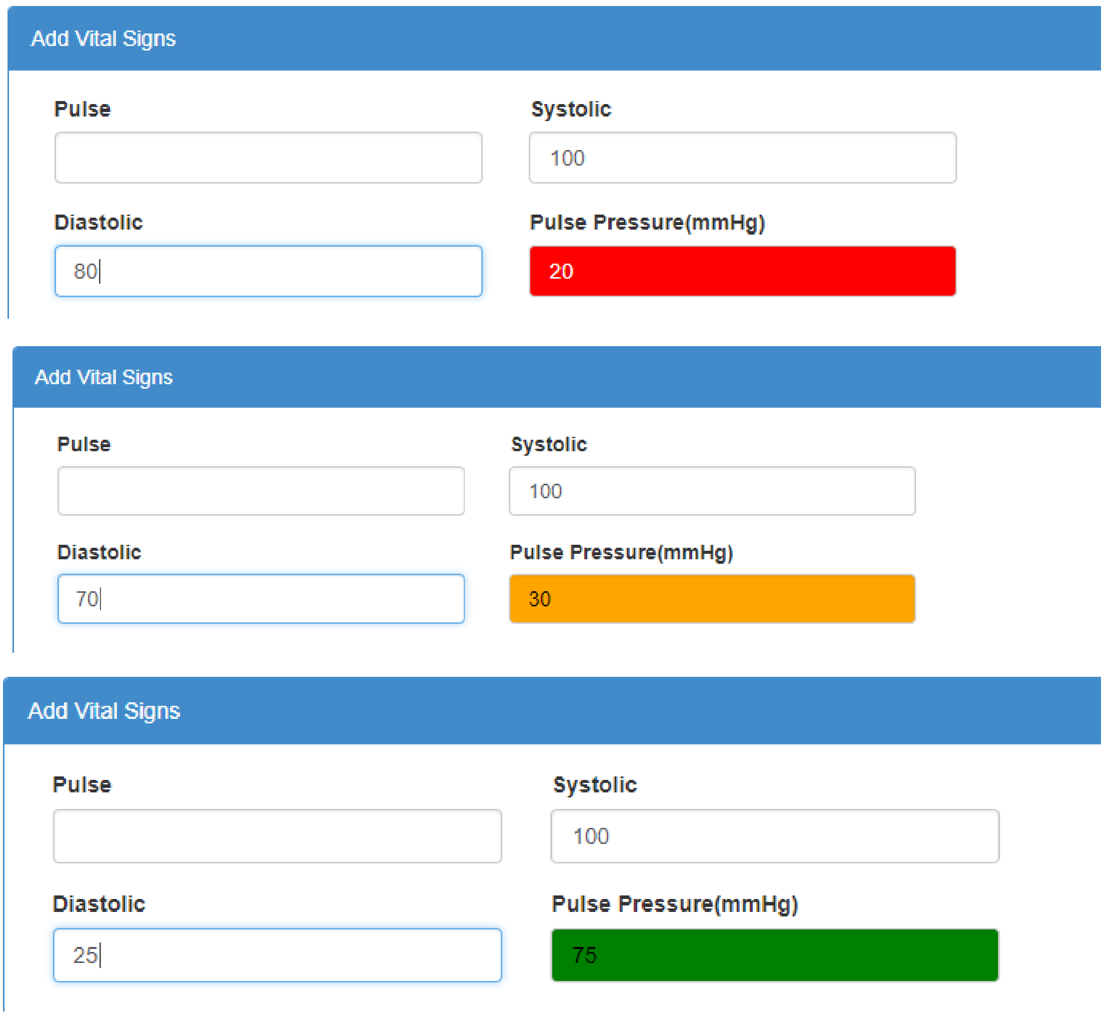
Pulse Pressure is calculated by using below equation.

Pulse Pressure = Systolic – Diastolic

If the PP > 30 display the box with Green Color

If the 25 > PP > 30 display the box with Orange Colour

If the PP > 25 display the box with Red Colour



Appendix B-11-Pulse Pressure Calculation

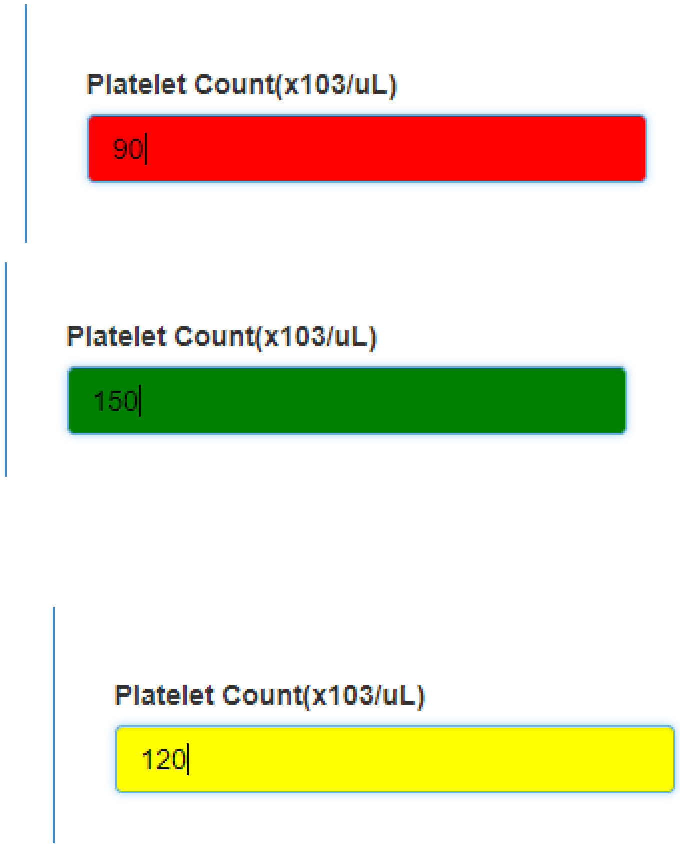
✓ Platelet Count

The color of Platelet count input box, should be changed as below.

If the Platelet Count > 150 , Green

If the Platelet Count < 100 , Red

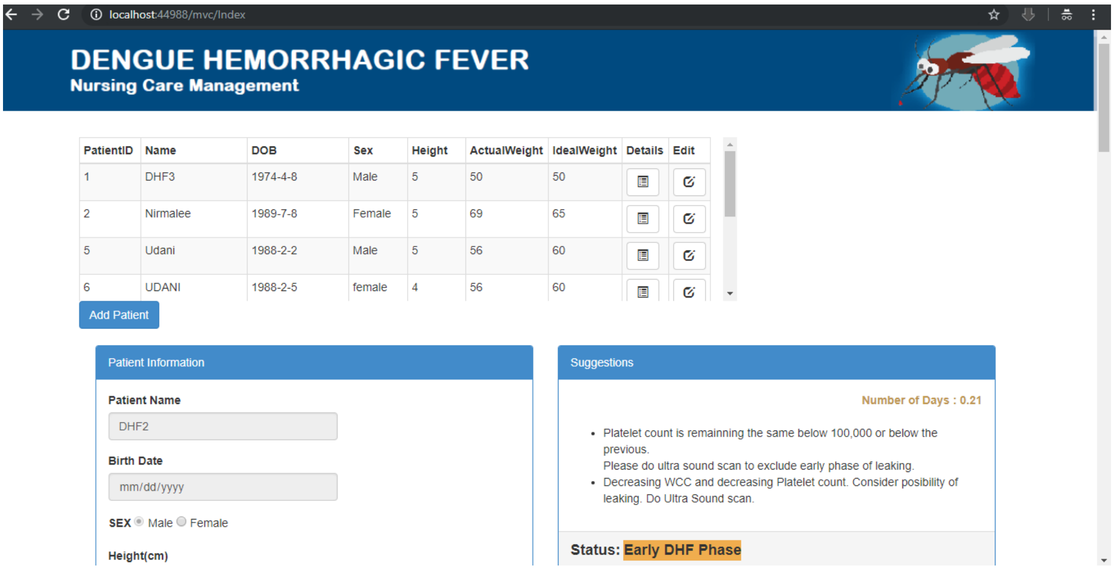
Otherwise Yellow



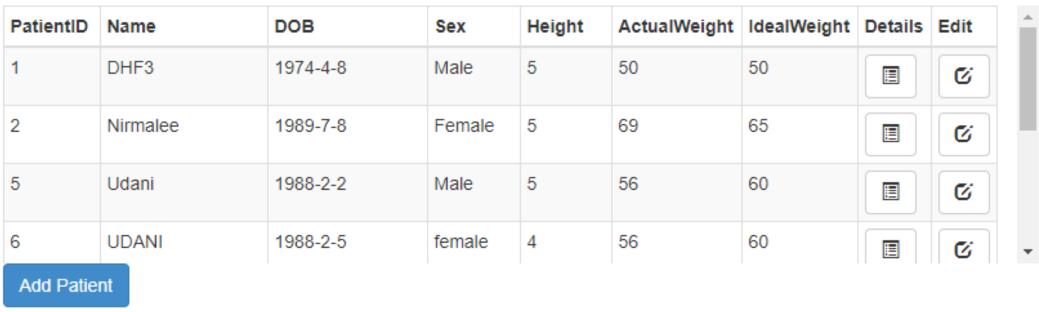
Appendix B-12-Color changing in Platelet Count

Appendix C

Interfaces of the Dengue Management System

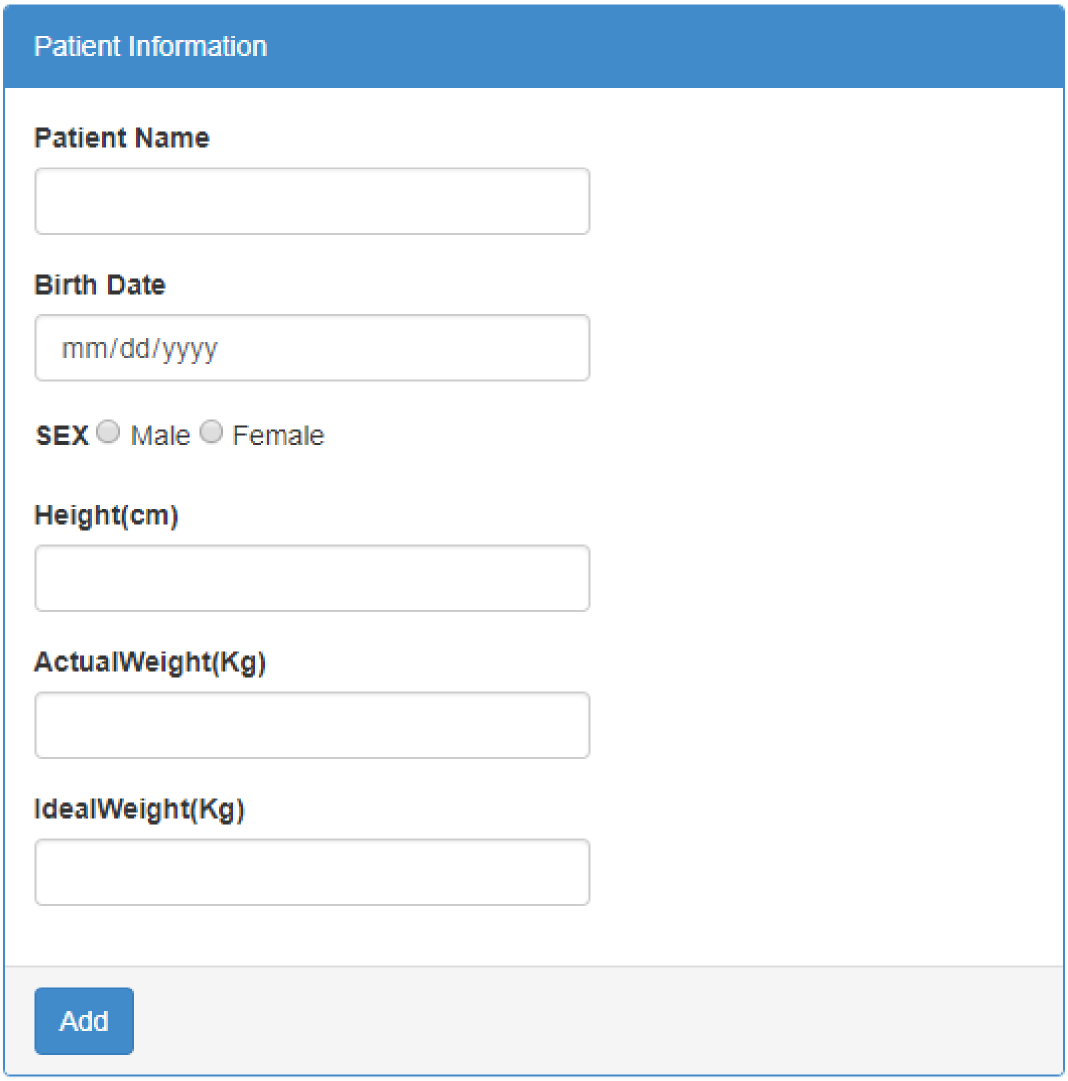


Appendix C-1-Home Page



PatientID	Name	DOB	Sex	Height	ActualWeight	IdealWeight	Details	Edit
1	DHF3	1974-4-8	Male	5	50	50		
2	Nirmalee	1989-7-8	Female	5	69	65		
5	Udani	1988-2-2	Male	5	56	60		
6	UDANI	1988-2-5	female	4	56	60		

Appendix C-2 - List of patients inside the Table


Patient Information

Patient Name

Birth Date

mm/dd/yyyy

SEX Male Female

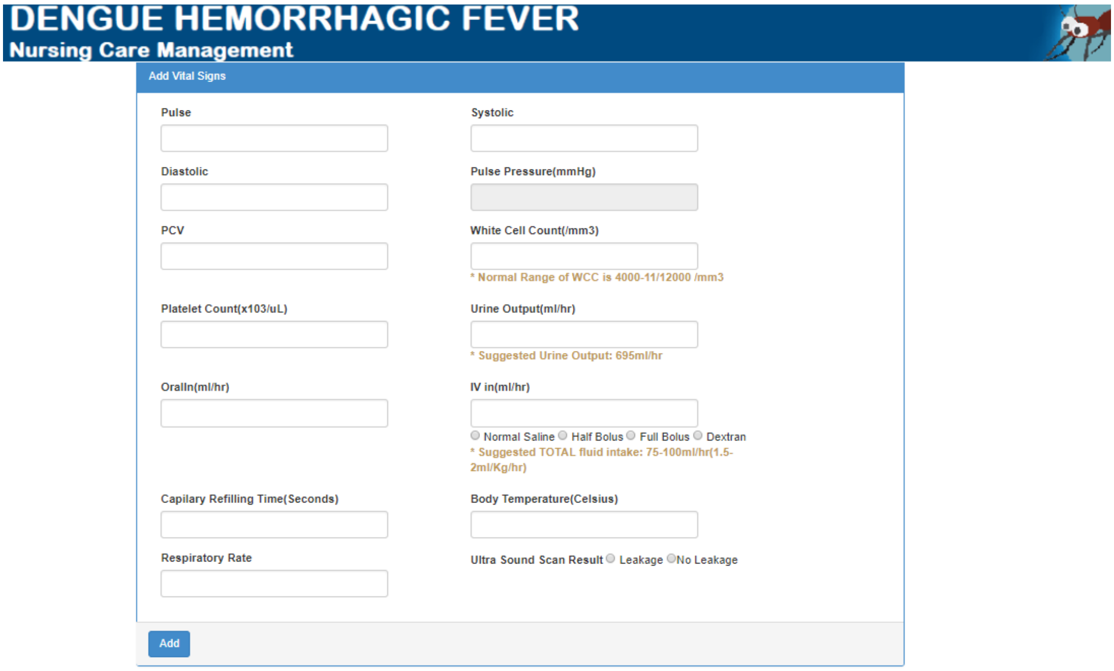
Height(cm)

ActualWeight(Kg)

IdealWeight(Kg)

Add

Appendix C-3 - Patient Registration Form



Appendix C-4 - Vital Sign Entering Window