MATERNAL HEALTH TRACKER WEB APPLICATION SYSTEM

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Declaration

I declare that this work has not been previously submitted and approved for the award of a bachelor's degree by this or any other University. To the best of my knowledge and belief, the documentation contains no material previously published or written by another person except where due reference is made in the documentation itself.

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Abstract

Excellent maternal healthcare in Kenya and the world at large is still a work in progress. The slow improvement in global maternal health has necessitated the healthcare sector to look for supplementary technological solutions. Delayed response to symptoms during antenatal care is a major cause of pregnancy related mortality in Kenya. Timely signal of abnormal symptoms during pregnancy leads to reduced risk of pregnancy-related complications in an expectant woman. This study aimed at assisting in reducing maternal mortality rate in the country, through development of a web application that analyses the daily input symptoms during pregnancy and timely signals any deviation from the normal expected symptoms. Rapid Application Development (RAD) methodology was used in building the system since the maternal health study had well-defined requirements. In addition, RAD methodology has an incremental approach that facilitated early testing of the system, and this was a determinant of whether the development was on the right track in terms of a working solution. The solution tracks pregnancy progress and issue a timely signal of any abnormal symptom and in the long run minimize the possibility of pregnancy-related complications.

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Abbreviations

ADA – Advanced Development for Africa

ANC – Antenatal Care

ART – Antiretroviral Therapy

CASE – Computer Aided Software Engineering

DBMS – Database Management System

DFD – Data Flow Diagrams (DFD)

EMR – Electronic Maternity Records

ERD – Entity Relationship Diagram

EWS – Early Warning Score

HIV/AIDS – Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome

IDE – Integrated Development Environment

IoT – Internet of Things

KimMNCHip – Kenya integrated mobile Maternal and Newborn Child Health information platform

LRS – Low-Resource Setting

MAMA – Mobile Alliance for Maternal Action

MDG – Millennium Development Goal

m-Health – mobile Health

MOTECH – Mobile Technology for Community Health

Ob/Gyn – Obstetrician/Gynaecologist

PPP – Public-Private Partnership

RAD – Rapid Application Development

SDG – Sustainable Development Goal

SDLC – Software Development Life Cycle

SMS – Short Messaging Service

SSAD – Structured Systems Analysis and Design

TB – Tuberculosis

UN – United Nations

UNAID – Joint United Nations Programme on HIV/AIDS

USA – United States of America

WHO – World Health Organization

ZMD – Zero Mothers Die

Definition of terms

Antenatal Care -Care given to an expectant woman to prevent potential health risks during pregnancy. (World Health Organization, 2016a)

Ob/Gyn -Obstetrician/Gynaecologist is the doctor that specializes in maternal health, specifically pregnancy.(Shiel, 2018b)

Maternal Mortality -Death of a woman during pregnancy or within 42 days of termination of pregnancy from any cause related to the pregnancy.(World Health Organization, 2016a)

Preeclampsia -High Blood pressure during pregnancy. (World Health Organization, 2016a)

Vital Signs -Important medical signs indicating body health status. They are temperature, blood pressure, pulse and breathing rate. (Johns Hopkins Medicine, 2020)

Chapter 1: Introduction

1.1 Background

Technology has been a massive game changer in the healthcare industry in Kenya and the world at large. This has led to a significant decline in pregnancy-related mortality. Despite this improvement, the health-related Sustainable Development Goals (SDG) indicators have it that the progress is way too slow to meet the target set for 2030. (World Health Organization, 2019)

In 2015, 2.6 million babies were stillborn while 303,000 women died from pregnancy-related complications globally. The maternal deaths could have been prevented had the women accessed quality Antenatal Care (ANC). (World Health Organization, 2016b).

The recommended ANC is 8 clinical visits before delivery. During these clinical visits, the women go through a series of tests, to monitor their health, identify possible risk factors and get counselled on diet and pregnancy issues. Expectant women experience body changes throughout the course of their pregnancy. Some changes are normal while others raise a red flag. These symptoms come any time regardless of whether it is time to visit the doctor or not. If the symptom is agitating, the woman would have an impromptu visit to the doctor, otherwise the woman would wait for the next clinical visit. A study on effectiveness of antenatal care services in Kenya shows that lack of check-up for pregnancy complications is associated with neonatal mortality in the country. (Arunda et al., 2017) A minor symptom, take headache as an example can indicate serious issue or non-serious issue. A woman alone cannot identify a risky symptom without a doctor's examination. When the woman decides to shelve this minor issue, yet it is a major health hazard for both her and the foetus, she is putting herself and her unborn child at risk.

In 2016, maternal mortality was the second leading cause of death for women of reproductive age globally. (World Health Organization, 2019) It is vital to monitor daily progress of an expectant woman as a supplement to the 8 recommended clinical visits in order to secure lives of women and children by identifying potential risks on time using technology.

1.2 Problem Statement

Delayed response to pregnancy symptoms during antenatal care is a major cause of pregnancy-related mortality in Kenya. (Mbithi & Onderi, 2016) The number of antenatal care (ANC) visits recommended is at least 8. (World Health Organization, 2016b). The scheduled visits are very important in identifying and mitigating potential health risks facing the mother and the child. Likewise, the period in between the ANC visits is equally important. A woman's pregnancy progress requires detailed and frequent attention. Maternal mortality per 100,000 births in Kenya stands at 510 as of 2015. (World Health Organization, 2019). The need to timely identify symptoms that pose a risk to the health of the woman and child has heightened the need for increased frequency of the monitoring of the woman's pregnancy progress. The challenge is experienced by expectant women in the country, and it has even been confirmed that the women in Kenya do not attend ANC clinics regularly hence placing the country among the greatest contributors to global maternal mortality. (Ochako & Gichuhi, 2016). The existence of the challenge can be dated back as far as the beginning of the twentieth century. The stakeholder that needs the solution are maternity hospitals as well as expectant women. The hospitals will be able to daily track the progress of expectant women thereby promoting timely identification of risk factors which in turn reduces pregnancy-related mortality.

1.3 Aim

This aim of this study was to develop a web-based maternal health application that assist in minimizing pregnancy-related complications through timely signal of abnormal symptoms in an expectant woman.

1.4 Specific Objectives

1) Analyse the current pregnancy tracking process from conception to birth.
2) Identify the baseline data of what constitutes a normal pregnancy.
3) Identify health data that may indicate possible abnormalities in the pregnancy.
4) Review pregnancy tracker application systems and techniques.
5) Develop a system that signals abnormal symptoms on time.
6) Test the developed system.

1.5 Justification

The solution tracks pregnancy progress and issues a timely signal of an abnormal symptom and in the long run minimizes the possibility of pregnancy-related complications. It bridges the gap between the ANC clinical visits since the expectant woman will be in constant communication with the doctor. The application gives each woman a satisfactory pregnancy journey as they will always know of their health status.

Expectant women stand to benefit from this system because early detection of potential risks equals higher chance of survival rate if the risk turns out life-threatening. The hospitals stand to benefit from the system since their doctors will be able to monitor their patients progress every day and this will promote accountability for their patients' health because the doctors will be required to give feedback to the patient. The system's most significant undertaking is to ensure accurate and timely signals of symptoms that would pose a health risk to either the expectant woman or the child.

1.6 Scope and Limitations

The system receives user input as symptoms and analyses it before giving the doctor the results of its findings for verification and feedback to the patient. It keeps track of daily progress of the patient's pregnancy.

The assumption in the project is that the doctors would respond within 24 hours of reception of the patient's progress. Suppose the doctors fail to respond on time, the integrity of the system would be compromised. The application also assumes the expectant woman would be visiting the same hospital throughout the pregnancy for the purposes of record-keeping in the application. This is a limitation because hospital consistency is not guaranteed as it depends on the patient. The application would be web-based and therefore means it requires internet connectivity to track pregnancy progress.

Chapter 2: Literature Review

2.1 Introduction

The Maternal Health Tracker System has a goal of minimizing pregnancy-related complications which eventually reduces maternal mortality rate. This chapter reviews literature about maternal health tracking systems. It consists of the current pregnancy tracking process detailed from conception to birth, baseline data of what constitutes a normal and abnormal pregnancy, maternal health tracker application systems and techniques, gaps identified from all the reviewed systems and the conceptual framework of the developed system.

2.2 Analysis of the current pregnancy tracking process from conception to birth

Maternal health is monitored during the ANC clinical visits. There are assessments that are specific to the stage of pregnancy the woman is in and there are also mandatory assessments for every clinical visit.

On the first ANC visit, the major parameters being observed are pregnancy status, birth plan and emergency plan. The pregnancy status requires data such as age, last menstrual flow and past pregnancies data. The Ob/Gyn (Obstetrician and Gynaecologist) performs syphilis test and Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome (HIV/AIDS) tests on the expectant woman and looks for a caesarean scar on her abdomen. On provision of the results of the HIV/AIDS test the expectant woman is counselled. (World Health Organization, 2016a)

On every other visit the Ob/Gyn will be performing several tests to determine the health of the expectant woman and her baby. Assessments conducted include checking for the duration of the pregnancy, review of her previous pregnancy records and take note of any pregnancy complications she had then as well as the treatments she received that time and inquiry about the hospital she plans to get her baby delivered. The choice of delivery hospital is important because it depends on the pregnancy. For instance, high-risk pregnancy can under no circumstance be delivered in a primary healthcare facility. Other inquiries are if she has had any vaginal bleeding since she last visited the ANC clinic, if she consumes alcohol, smokes tobacco or any other form of drug abuse and if she is exposed to other people that smoke tobacco at home. She gets screened for anaemia and pre-eclampsia and after results are

analysed, she is given treatment and advise accordingly. The syphilis test and HIV/AIDS test that were performed on the first visit determine the course of every other visit as these results would be reviewed on every other visit. For syphilis if it was negative, the expectant woman gets advice on how to prevent it and if it was positive, relevant follow-up is done and retest is conducted to see if the condition has been treated or if she needs more medication and the necessary action is taken with accompanying advice from the Ob/Gyn. For HIV/AIDS if it was negative, the expectant woman is given advice on how to prevent it and if it was positive, she is advised on how to manage it since it is a non-curable but manageable disease and then ART (Antiretroviral Therapy) drugs is administered to her. A major assessment on every visit is the response to the expectant woman's observed signs and volunteered problems. The expectant woman consults the doctor and inquires about any concern she has. The Ob/Gyn will determine the necessary course of action and administer treatment and drugs if need be. Finally, the woman is given advice on nutrition, self-care best practices, substance-abuse, family-planning, labour signs and danger signs that she should look out for. She is also reminded the importance of following the ANC visit schedule. (World Health Organization, 2016a).

All findings are recorded on a patients management system, the birth plan is also recorded, necessary treatments are administered, if the expectant woman is HIV-positive she is given ART drugs and the next scheduled visit is recorded on the maternal card. This same procedure is repeated for every ANC visit and some additional tests conducted depending on the stage of the pregnancy. (World Health Organization, 2016a). The expectant woman is given a booklet that contains all her pregnancy information written down on every ANC clinical visit.

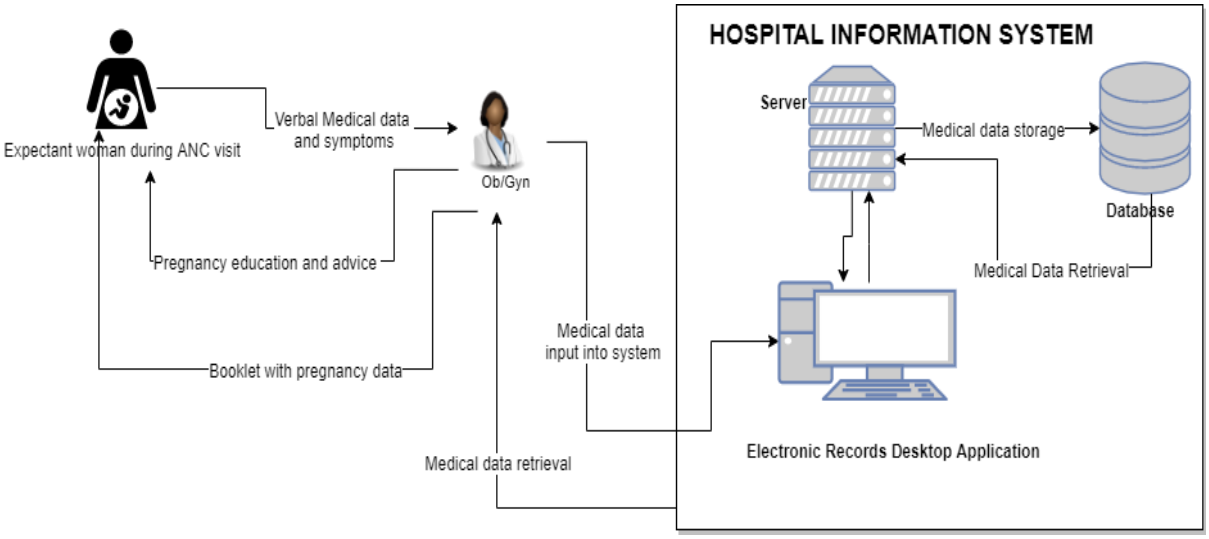

Figure 2.1 Framework for current pregnancy tracking process

2.3 Baseline data of what constitutes a normal pregnancy

Pregnancy comes along with significant body changes that cause the woman discomfort. Most discomforts are normal while others may indicate possible risk of a pregnancy complication. This section highlights the vital signs that are monitored to determine the safety of the pregnancy. It also highlights the symptoms that have been identified by obstetricians and gynaecologists as normal for all expectant women. This data is the baseline for determination of pregnancy state as a normal and healthy pregnancy.

2.3.1 Normal vital signs in pregnancy

This table illustrates the specific figures considered normal for vital signs such as temperature, heart rate, respiratory rate, blood pressure and oxygen saturation. It varies as the pregnancy progresses and is slightly different from a non-pregnant woman.

Vital sign	**Measurement unit**	**Non-pregnant woman**	**First trimester**	**Second Trimester**	**Third Trimester**
Systolic blood pressure	**mmHg**	90 to 120	94.8 to 137.6	95.6 to 136.4	101.6 to 143.5
Diastolic blood pressure	**mmHg**	60 to 80	55.5 to 86.9	56.8 to 87.1	62.4 to 94.7
Heart Rate	**Beats per minute**	60 to 100	63.1 to 105.2	67.4 to 112.5	64.5 to 113.8
Respiratory rate	**Breaths per minute**	12 to 20	8 to 24	8 to 24	8 to 24
Oxygen Saturation SpO2	**Percentage (%)**	95 to 100	94.3 to 99.4	92.9 to 99.3	93.4 to 98.5
Temperature	**(℃) Celsius**	36.5 to 37.3	35.55 to 37.51	35.35 to 37.37	35.37 to 37.35
	(℉) Fahrenheit	97.8 to 99.1	95.99 to 99.52	95.63 to 99.27	95.67 to 99.23

Table 2.1 Normal Vital Signs in Pregnancy(Focus Information Technology, 2020)

2.3.2 Normal expected symptoms of an expectant woman

Pregnancy is usually accompanied by notable hormonal changes. These changes slightly interfere with the normal functioning of some body parts of the expectant woman. Increased hormone levels cause discomforts such as nasal congestion, nausea and vomiting, swollen and bleeding gums, constipation, increased vaginal secretion, heartburn and indigestion and breast changes. (Cleveland Clinic Foundation, 2015). Pregnancy hormones dry up nasal lining causing inflammation. Nausea and vomiting occur when the expectant woman has an empty stomach, it is common in the morning and is widely referred to as morning sickness. The hormones cause overproduction of thick, white or clear, odourless, non-irritant vaginal discharge. The hormones also cause the digestive system to work slowly and this results to heartburn and indigestion. Breasts become larger as the hormones prepare them for milk production. A thick fluid called colostrum might leak from the breast. (Cleveland Clinic Foundation, 2015).

The developing baby inside the uterus exerts pressure on the surrounding organs such as bladder, stomach and rectum as well as on the supporting organs such as the legs and spine. The pressure results in discomforts such as backache, haemorrhoids, frequent urination, heartburn, swelling of the legs and varicose veins. Haemorrhoids are swollen veins at the anus because of pressure by the uterus on the rectum. Frequent urination is caused by pressure on bladder by the uterus. When the uterus outs pressure on the stomach it pushes stomach acid upwards causing acid reflux hence heartburn. Swelling of the legs and feet a condition medically termed as oedema, which is swelling due to excessive fluid retention is caused by the pressure of the baby on the lower body. The same pressure on lower body causes slow blood flow leading to varicose veins, a condition whereby the veins become swollen. (Cleveland Clinic Foundation, 2015).

Other common discomforts include headache, fatigue, shortness of breath abdominal pains and muscle tightening. Headache can indicate a health risk and in some cases it is normal. Fatigue is normal due to baby energy requirements; however, it can be a possible indicator of anaemia, a condition whereby the red blood cell count is low. Abdominal pains and muscle tightening result from the stretching tissue supporting your growing uterus. (Cleveland Clinic Foundation, 2015). It is worth noting that all these symptoms are usually anticipated in every pregnancy but not all symptoms are experienced by everyone as women's bodies are different.

2.4 Health data that indicate possible abnormalities in the pregnancy

Table 2.3.1 shows the baseline data for normal vital signs in pregnancy. If at any point the values of the expectant woman diverge from the baseline, then it signals danger and therefore the woman should seek immediate medical care. This section highlights the symptoms that indicate underlying high-risk health complications.

Fever of 38 degrees Celsius or more is an indication that the body is responding to an infection. (More, 2017). Heavy vaginal bleeding in the first trimester may indicate ectopic pregnancy, miscarriage or implantation bleeding of pregnancy. (Kamble et al., 2017). Other symptoms that may indicate serious underlying conditions are pain in arms, legs or chest, blurred vision, severe headaches, swelling of hands, fingers or face, unusual vaginal discharge, pain while urinating, fainting, dizziness, severe diarrhoea and vomiting and severe abdominal pain. (Cleveland Clinic Foundation, 2015). Gestational diabetes is the diabetes one gets when they are pregnant and had no diabetes prior to the pregnancy. It happens when the blood sugar levels are higher than normal due to hormonal changes. This condition if left untreated leads to further dangerous complications. (Hod et al., 2015). Pre-eclampsia is a pregnancy induced high blood pressure. Table 2.3.1 indicates the expected blood pressure of an expectant woman. If it exceeds this standard value, it is considered dangerously high. An expectant woman can have severe pre-eclampsia with absolutely no symptoms, very risky. However very few expectant women experience severe headaches, pain beneath the ribs, vomiting and swelling of the face, hands or feet as indications of pre-eclampsia. (Preeclampsia Foundation, 2020).

Expectant women especially from Low-resource Setting (LRS) are less aware of danger signs.(Onono et al., 2019). Childbirth is equally as dangerous in first world countries, just as it is in third world countries. (Page, 2019). Therefore, an expectant woman should seek immediate medical attention should they experience any of the symptoms described.

2.5 Pregnancy Tracker Application Systems

2.5.1 BabyScripts

The prime purpose of ANC visits is to monitor pregnancy progress. The evolution of Internet of Things (IoT) has greatly transformed medical solutions. One such transformation has been observed at the maternal health sector where some health check-ups previously done in a

maternity clinic has now devolved to being done remotely by the expectant woman herself. BabyScripts, an android mobile application was developed in the United States of America(USA) in 2014 to monitor weight and blood pressure of expectant women remotely and to disseminate pregnancy information to them.(Marko et al., 2019).

The application disseminates pregnancy information to the expectant woman in accordance to her gestational calendar. This data informs her on nutritional requirements, healthy weight gain, danger signs that may indicate possible risks, how to mitigate these risks and advice on self-induced unhealthy habits such as smoking, alcohol consumption and drug and substance abuse.(Marko et al., 2019). The expectant mother self-checks her blood pressure and weight using the Wi-Fi-connected scale and blood pressure hand cuff. These provide results and alerts that issue early warnings on possible risk of disorders like preeclampsia and obesity. (Marko et al., 2019).

Ever since its launch in 2014, the application has attracted a user population of over ten thousand. Following the success of medical applications that monitored high risk diseases such as diabetes, BabyScripts hypothesized that it can be done for pregnancy monitoring too. The antenatal care application aimed at reducing in-person visits and provide a virtual care model for expectant women. (Marko et al., 2019).

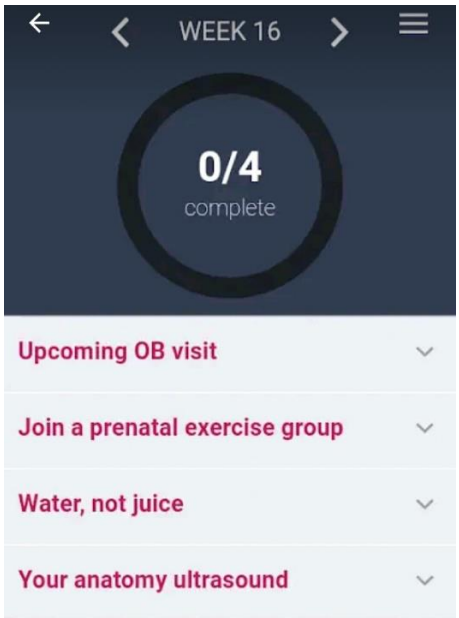

Figure 2.2 BabyScripts Application Review

2.5.2 Zero Mothers Die

Maternal mortality per 100,000 births globally stands at 216 as of 2015. (World Health Organization, 2019). In a joint effort by Advanced Development for Africa (ADA), Millenia2025 "Women and Innovation" Foundation and UniversalDoctor Project to reduce maternal mortality, a global initiative named 'Zero Mothers Die' (ZMD) was formed. Its main objective is to save the lives of expectant women and their babies by disseminating information about pregnancy and emergency care.(Silva et al., 2019)

The android mobile application has three user modules: expectant woman, a new mother and a health worker. The module for the expectant woman is divided into weeks for tracking the pregnancy (Silva et al., 2019). The module for a new mother is divided into months for the purposes of monitoring child growth and development up to their first birthday. The module for primary healthcare workers contains audio-visual resources for continuing education. (Silva et al., 2019) The application gives vital maternal, new-born and child health information such as tips for a healthy pregnancy, tips for care of new-borns, HIV-positive breastfeeding and Tuberculosis (TB) in lactating women. A unique feature of the application is the provision of guidelines to frontline health workers to bridge the knowledge and skills gap. The application has its information tailored in a language that will not alarm the expectant woman for no apparent reason. (Silva et al., 2019).

The global partners of ZMD initiative include Global Partnerships Forum, Joint United Nations Programme on HIV/AIDS (UNAIDS) and Airtel. The main agenda of the initiative is to fulfil the United Nations (UN) SDGs of good health and well-being. (Silva et al., 2019) The application is multilingual and even has Swahili as one of the languages. This application has really improved maternal awareness of pregnancy.

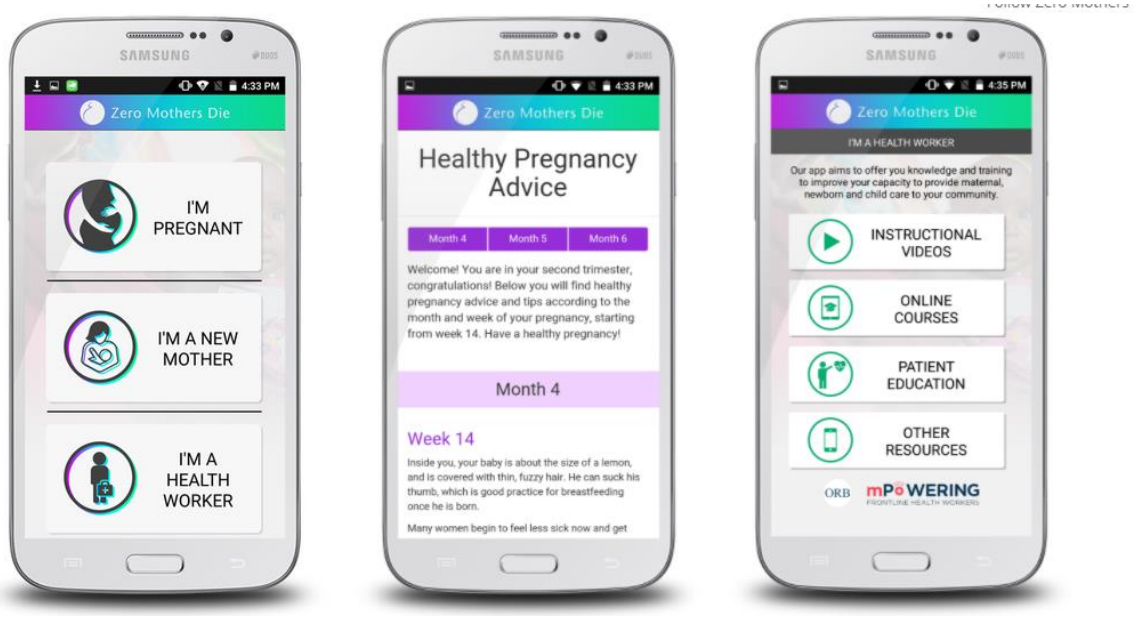

Figure 2.3 Zero Mothers Die Application Review

2.5.3 FoetusCare

Pregnancy is a biological phenomenon whereby a foetus develops within a female body.(Shiel, 2018a). The gestation period is accompanied by notable body changes. FoetusCare was developed in India in 2015 to disseminate beneficial information to expectant women to help them understand the changes that come along with being expectant. (Bharathi & Nirmalrani, 2016).

The mobile-based android application clearly describes expected symptoms to the expectant woman every week and allows communication with the doctor via email. This minimizes the possibility of anxiety among expectant women as they have the assurance of safety right at the comfort of their smart-phones. (Bharathi & Nirmalrani, 2016). In addition, FoetusCare issues notifications to the woman about important dates , gives day-to-day dietary guidance on calorie intake, gives fitness advice on healthy weight gain weekly, provides a visualization of foetal development stages and determines the due date of the pregnancy. (Bharathi & Nirmalrani, 2016).

The medical world has been revolutionized by technology. Medical solutions now include technological applications as a complementary aid in health management. FoetusCare is one

such medical-based application as it cuts down the possibility of physical hospital visits by providing communication channel between the expectant woman and the gynaecologists and obstetricians. (Bharathi & Nirmalrani, 2016).

2.6 Techniques used in tracking maternal health

2.6.1 Short Messaging Service

There are 5 billion mobile phone subscribers worldwide. (Global Systems for Mobile Communications, 2017). This creates solid opportunities for mobile Health(m-Health) to be used to improve health especially in regions with limited healthcare access.

Kenya integrated mobile Maternal and Newborn Child Health information platform (KimMNCHip) is a national scale mobile Health (mHealth) initiative for maternal and child health that aims to support the country in fulfilling Millennium Development Goals (MDGs) for reducing child mortality and improving maternal health. (Kariuki & Okanda, 2017). Women register and provide their due date then receive push messages and voice messages and access to call-in advisory hotlines and information databases. (Kariuki & Okanda, 2017)

Mobile Alliance for Maternal Action (MAMA) is a global mHealth Public-Private Partnership (PPP) that aims to improve maternal health by disseminating health information to expectant women and new mothers. (Mechael et al., 2019). In Kenya, MamaTips was developed under MAMA and it sends weekly messages of pregnancy information during pregnancy and up to the child's first birthday. (Gichimu et al., 2018). In South Africa, MAMA launched MomConnect which enrols every expectant woman in the country to a national pregnancy database and sends maternal health information weekly. (Peter et al., 2015).

Mobile Technology for Community Health (MOTECH) in Ghana sends voice and text messages with vital health information to expectant women and new parents in their local language from pregnancy through to 12 months post-birth. (Willcox et al., 2019)

Short Messaging Service (SMS) seems to be quite popular in dissemination of maternal health information. It is a technology that has become widespread because of the popularity of mobile devices.

2.6.2 Mobile Applications

Native mobile applications run on smartphones. According to Statista, there are 3.5 billion smartphone users in 2020. (O'Dea, 2020). This is an opportunity for mHealth to improve healthcare by provision of information and having a platform that bridges the gap between doctor and patient. Mobile applications are the used with Internet of Things (IoT) for applications that involve direct data capture from the source and made available for the user to view on the mobile application.

Health-e babies application is a maternal mobile application that was developed for information provision about the pregnancy to increase maternal confidence and minimize anxiety. (Dalton et al., 2018). The application provided information regarding diet, foetal development, maternal physical changes, fitness and information regarding emergency situations. (Dalton et al., 2018). WomanLog is a pregnancy tracking mobile application that serves as Electronic Maternity Records (EMR). The expectant woman records on the calendar the number of foetal movements, contraction duration, symptoms she experiences, weight and medical appointments. (Fonseca et al., 2019). There are applications that provide a social interactive forum and others are specialized for women with specific pregnancy related complications such as Gestavida Pregnancy is for expectant women with gestational diabetes. (Fonseca et al., 2019).

Mobile applications are preferred due to the penetration of the devices. They are also portable and easy to use, and this makes them a promising platform for maternal mobile healthcare.

2.6.3 Internet of Things

Direct data capture by sensors connected to the Internet is known as Internet of Things (IoT). It is applicable in minimizing human data entry errors. (Waher, 2015) In the healthcare industry it has been applied in remote health monitoring, chronic disease monitoring and fitness programs on mobile devices such as the Samsung Health. (Riazul Islam et al., 2015).

IoT has rapidly gained popularity in maternal health leading to implementation of maternal remote health monitoring systems which have significantly contributed to reducing maternal mortality. A study by (Amala & Mythili, 2017) proposed an IoT-based solution for capturing vital signs of expectant women. Different wireless sensors capture blood pressure, heart rate

temperature and foetus movement then the data is transferred using IoT technology and the output is accessed on the mobile device of the expectant woman. (Amala & Mythili, 2017).

Another application is the Early Warning Score (EWS) systems for obstetric patients that assign increasing scores to the vital signs collected using IoT technology through sensors. If the scores exceed the standard score then an alert is triggered.(Kumar et al., 2017)

A local study by (Musyoka et al., 2019) proposed implementation of a 24-hour blood pressure monitor for preeclampsia, a condition common in expectant women. Readings indicating risk are sent as alerts to the assigned caregiver for rapid action. Data is collected by smartwatches and through IoT technology it is transmitted to smartphones.(Musyoka et al., 2019)

2.7 Gaps identified in the current maternal health tracking systems

Section 2.2 contains the analysis of the pregnancy tracking process from conception to birth which is done by ANC clinical visits. The ANC clinical visits are spaced, this means there is no way to communicate with the Ob/Gyn in between the ANC clinical visits. The expectant women are expected to communicate their cumulative concerns during the ANC clinical visits. There is a possibility that the health concerns that have been shelved to wait for the ANC visits, might have been an indicator of an underlying issue that gets worse as time goes by. There is need to have a doctor-patient communication channel to prevent such occurrences that eventually lead to pregnancy-related complications.

2.8 Conclusion

From the literature review ANC clinical visits was identified as the means used to track the progress of an expectant women. There have been numerous efforts to reduce maternal mortality in the entire world. Mobile applications have been programmed to provide maternal care information to women, SMS technology has been employed in provision of pregnancy education and recently IoT enabled devices have been innovated to retrieve data directly from the expectant woman. All these efforts have contributed to reduction in maternal mortality rate.

The current mode of tracking pregnancy is through ANC clinical visits. Gaps identified from this mode of pregnancy tracking is that there is no way to communicate to the Ob/Gyn in between the ANC visits. The developed system addresses this gap by incorporating a feature

to daily track symptoms and send an analysis to the Ob/Gyn then the expectant woman receives back their health status. This system aims at minimizing pregnancy related complications through timely signal of abnormal symptoms. It is worth noting that the developed system does not aim to replace the current system that uses ANC clinic visits to track pregnancy, it rather aims at providing a supplementary means to track pregnancy remotely every day during the days when the expectant woman does not have an ANC clinical visit.

2.9 Conceptual Framework

This is an architectural illustration of how the developed system's components relate to each other. The expectant woman records her daily symptoms that is transmitted over the internet then gets stored in a database then receives health worker feedback retrieved from the server database to inform her of her health. She also receives maternal health information to the from the database to help in pregnancy management.

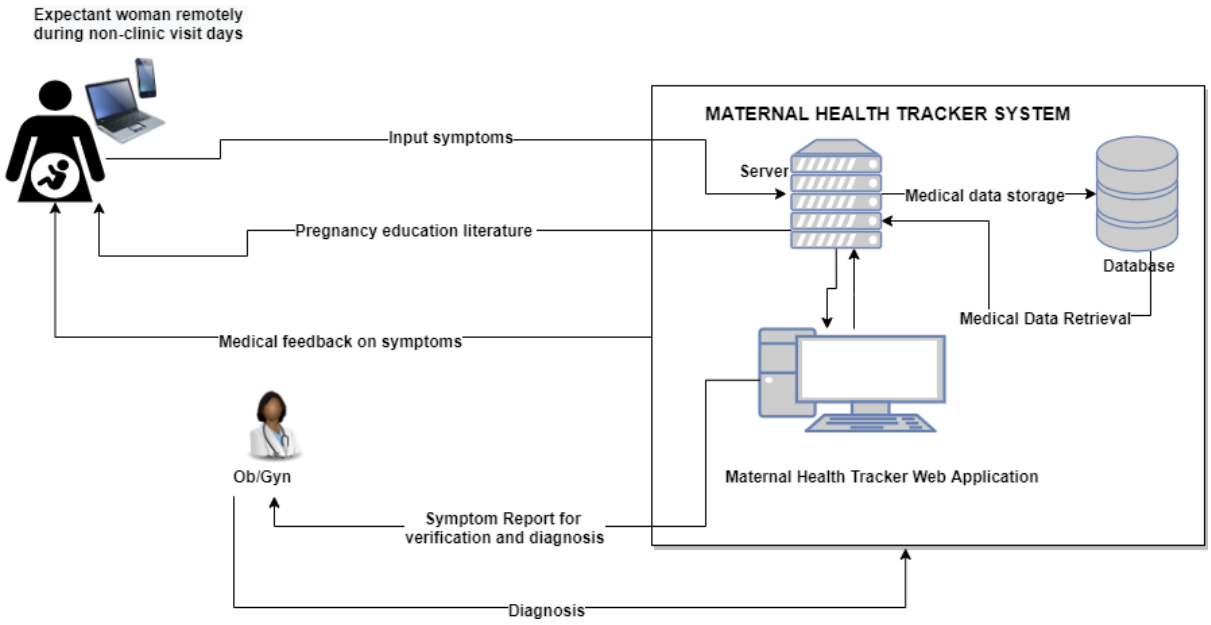

Figure 2.4 Conceptual Framework

Chapter 3: System Development Methodology

3.1 Introduction

Software Development Life Cycle (SDLC) is a framework used to build information systems in phases that is, planning, analysis, design and implementation. (Dennis et al., 2012). To implement this SDLC, an accepted approach known as the System Development Methodology is used and it is the focus of this chapter. Other highlights of this chapter include development approach, tools and techniques, testing methods, domain of execution and system modules and architecture. The aim of this study was to develop a web-based maternal health tracker that assists in minimizing pregnancy-related complications through timely signal of abnormal symptoms. To achieve this, Rapid Application Development (RAD) methodology was used because the study had well-stated requirements with an expected delivery timeframe of 6 months.

3.2 Rapid Application Development

RAD is an iterative methodology that uses prototyping and consists of four phases that is, requirements planning, user design, construction and cutover. (Shelly et al., 2012).

In this phase, users and analysts jointly identify objectives, business needs, project scope, constraints and system information requirements. (Shelly et al., 2012).

3.2.1 Requirements planning

In this phase, users and analysts jointly identify objectives, business needs, project scope, constraints and system information requirements. (Shelly et al., 2012). In this maternal health study, users who are expectant women and Ob/Gyns were be engaged in identification of information requirements and business needs. Data was gathered from different sources then analysed. Objectives, business needs and information requirements were derived from this analysis and was used to arrive at finalized requirements specification.

3.2.2 User Design

This phase is user oriented. models and prototypes that represent all processes, outputs and inputs are developed. (Shelly et al., 2012). In this study, the analyst developed models and prototypes of system processes like gestation age tracking, outputs like symptom analysis and

inputs like experienced symptoms. The expectant women and the Ob/Gyns gave their feedback on the models as the analyst made necessary modifications based on the user feedback. This process was iterated until the users were satisfied with the system model.

3.2.3 Construction

This phase consists of actual system development as the users still continue to engage in feedback for improving the system. (Shelly et al., 2012). In this study, the analyst began coding the system as she received relevant feedback from the expectant women and Ob/Gyns. The entire developed system was built in this phase.

3.2.4 Cutover

This being the final phase, the tasks to be done include testing, data-conversion, user training and changeover to the new system. (Shelly et al., 2012) In this study, tests were conducted using test-data to validate that the system functioned as was planned in the beginning of the project.

3.3 Deliverables

The modules developed for the system are Patient (Expectant Woman), Doctor(Ob/Gyn), Clinician, Data Manager and Administrator.

The patient module includes:

1. Gestation age tracker – It calculates daily the gestation age of the woman.
2. Symptom recorder – It allows recording of daily symptoms that get analysed by the system and sent to the doctor for diagnosis.
3. Medical Response – Contains the response from the Ob/Gyn regarding the symptoms recorded.
4. Vital Signs – It contains vital signs of the expectant woman like blood pressure.
5. Pregnancy medical data – It contains medical data of the expectant woman about her pregnancy.

The Doctor (Ob/Gyn) module includes:

1. Pregnancy progress update – Ob/Gyn records the maternal health of every user as well as update their progress on every ANC visit.
2. Daily Symptom Report – It contains the reports of symptom analysis of every woman and the Ob/Gyn will be able to respond to the report and provide feedback to the expectant woman.

Data Manager module contains:

1. Create, Read, Update and Delete Vital Signs – The data manager manages the normal vital signs. This data is used as baseline to check for deviating vital signs.
2. Create, Read, Update and Delete Abnormal and Normal Symptoms – Contains normal and abnormal symptoms for pregnancy and is used as a baseline for the analysis of the patients' symptoms.

Clinician module contains:

1. Create, Read, Update and Delete Patient Vital Signs – The clinician manages the normal vital signs in this section commonly referred to as triage.
2. Create, Read, Update and Delete Patient Medical Data– The clinician manages the patient medical data such as medical history, allergies and all medical biodata and patient information as well.

3.4 System Development Tools and Techniques

The programming language that was used is JavaScript because it is dynamic and allows interactivity which is needed for this system. The Database Management System (DBMS) that was used is MySQL because it has features like automation, security and performance that are requirements of this maternal health system. It is a reliable, stable and opensource DBMS. The Integrated Development Environment (IDE) to be used is Visual Studio. Programming framework that was used is React because it is a powerful JavaScript framework that allows creating reusable components hence reducing the development time. The IDE also has Computer Aided Software Engineering (CASE) tools that were used to test the system for syntax errors.

3.5 Domain of execution

The domain of execution was web -based since web-based applications have compatibility that spans across all devices like desktop, tablet or phone. The maternal health application was intended to be for expectant women, and they need a platform that accommodates all devices and is easily available.

Chapter 4: System Analysis and Design

4.1 Introduction

This chapter highlights the system architecture, requirements gathering as well as the design diagrams. The approach applied in this maternal health system was Structured Systems Analysis and Design (SSAD). This approach is sequential one whereby the basic processes identified are decomposed fully into subprocesses until the vital system components are identified and are clearly defined. It was appropriate for this study because this maternal health system contains broad functionalities that required to be decomposed into small sub-processes and their relationships identified and hence the need to use a functional-programming approach.

4.2 Requirements Gathering

The methods used in gathering the requirements for this system was mainly questionnaire which is quantitative. I distributed different questionnaires to the mothers and the obstetricians, respectively. From obstetricians I was able to know how they manage pregnancies and from the mothers I was able to get to know how their pregnancy journey was in terms of management, pregnancy literacy, frequency of doctor-patient interaction and in case they had a complication how they found out about it. Attached at the appendix is a snapshot of the questionnaire. I also used document review to gather information as much as I could about pregnancy. I also got insights from studying existing applications that have tried to solve problems regarding maternal health.

4.3 System Requirements

4.3.1 Functional Requirements

These are requirements that define what tasks the software should perform as well as its capabilities. (Dennis et al., 2012). They include:

1. The system must allow every user of the system to self-register.
2. The system must allow the clinician to create, update and delete the patient medical data and vital signs when necessary and on every visit respectively.
3. The system must be able to track gestational age of an expectant woman.
4. The system must allow the expectant woman to record her daily symptoms.
5. The system must be able to analyse the symptoms recorded by the expectant woman.
6. The system must allow the Ob/Gyn to record the pregnancy biodata of every expectant woman and record ante natal care on every visit.

7. The system must be able to generate a report with contents of analysed symptoms for the Ob/Gyn.
8. The system must allow the Ob/Gyn to record response to the symptom reports.
9. The system must be able to generate a report with contents of Ob/Gyn feedback for the expectant woman.
10. The system must generate notifications for both the expectant woman and the Ob/Gyn.
11. The system must allow the data manager to create, update and delete the information in the database that is used for analysis.

4.3.2 Non-functional requirements

These are the 'characteristics the system should have'. (Dennis et al., 2012). They include:

1. The system should have a good response time.
2. The system should have a friendly user interface.
3. The system should run on any web browser.

4.4 System Architecture

The system architecture is a visual illustration of the environment of implementation of the developed system. Both the expectant woman and the Ob/Gyn require internet connectivity and a web enabled device. Data Manager, Clinician and Administrator use the medical centre network.

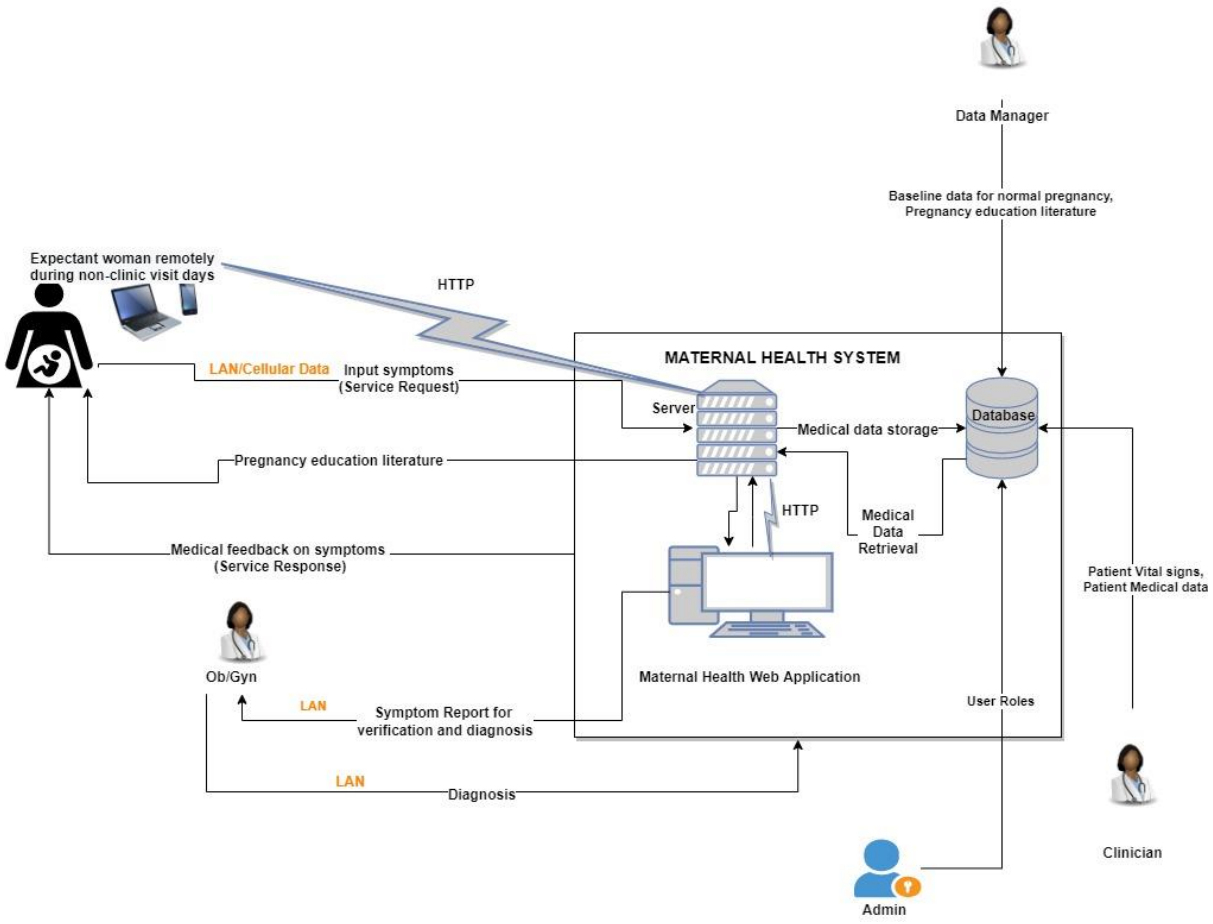

Figure 4.1 System Architecture

4.5 System Analysis

4.5.1 Context diagrams

'A context diagram shows the entire information system as if it were a single process.'(Shelly et al., 2012). The context diagram was used in giving an overview of the entire system with every user and their inputs into the system as well as outputs from the system.

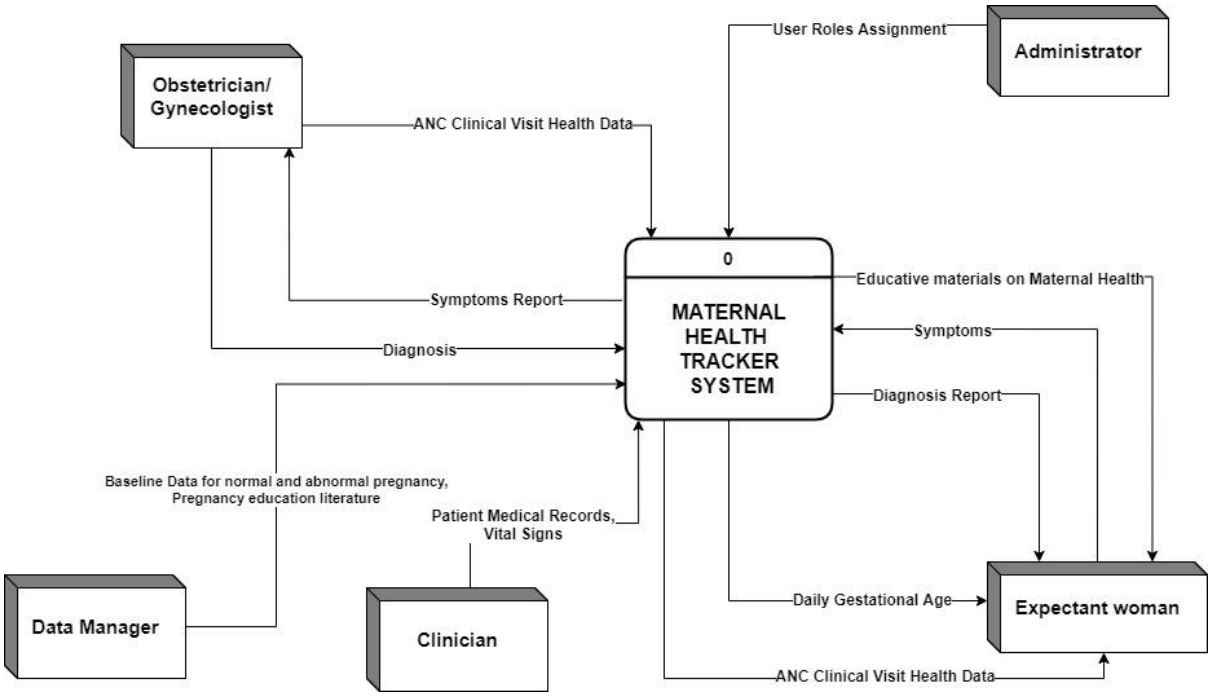

Figure 4.2 Context Diagram

4.6 System Design

'System design is the determination of the overall system architecture consisting of a set of the physical processing components, hardware, software, people and the communication among them, that will satisfy the system's essential requirements.' (Dennis et al., 2012). Here are the design diagrams I used,

4.6.1 Data Flow Diagrams

Data Flow Diagrams (DFDs) 'show how the system stores, processes and transforms data.' (Shelly et al., 2012). Level 0 and Level 1 DFDs were used in the maternal health system to provide a graphical and detailed illustration of the transformation of input data into information. For example, input symptoms were transformed into conclusive results of the condition the expectant woman may be suffering from.

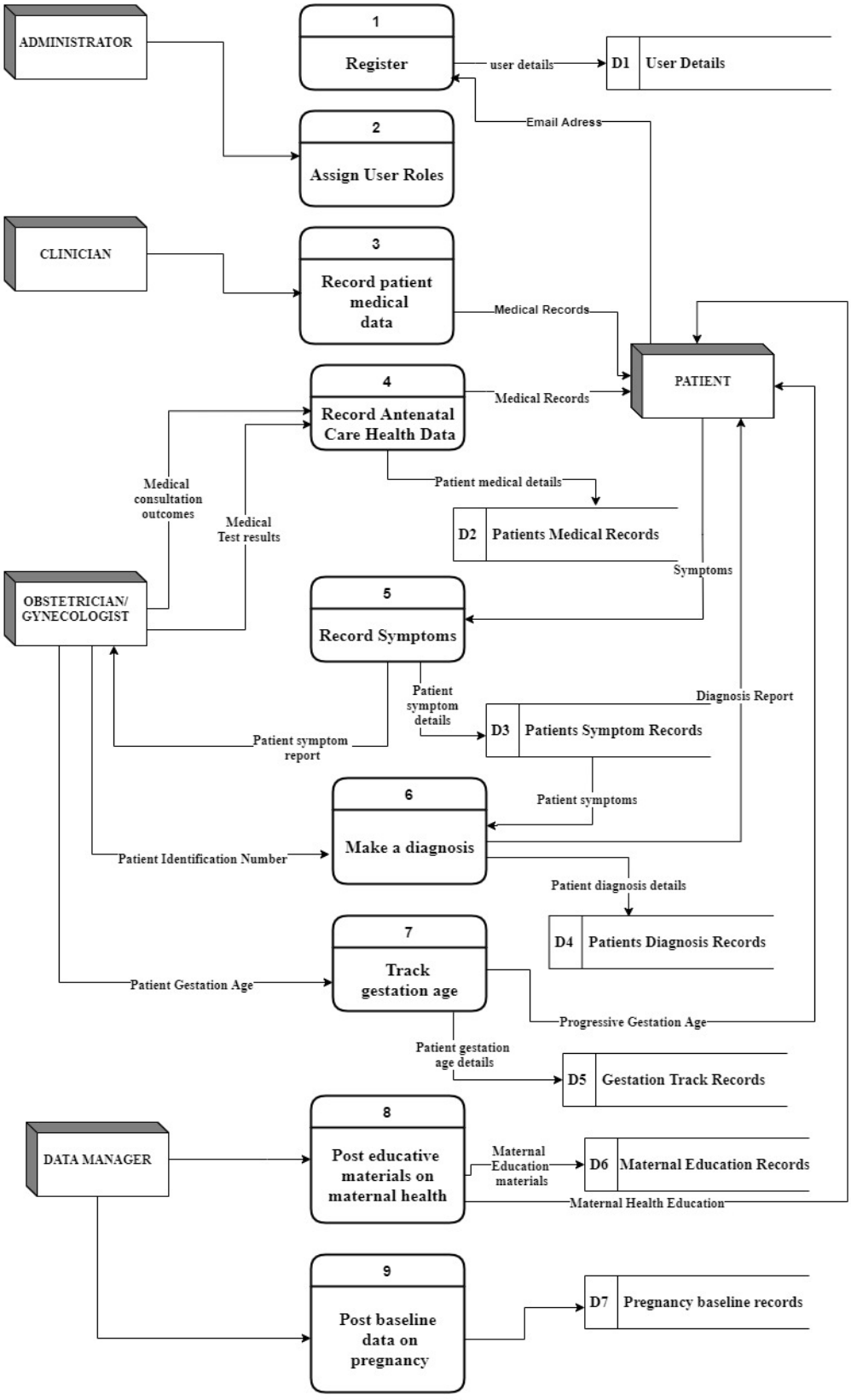

Figure 4.3 Data Flow Diagram Level 1

4.6.2 System-Entity Interaction

This flowchart shows how each entity interacts with the other entities and the system.

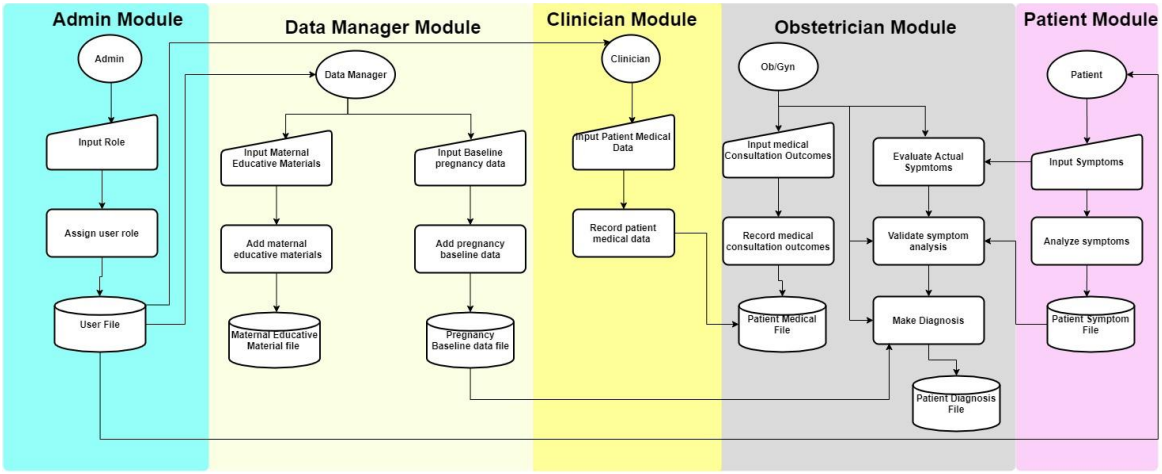

Figure 4.4 System-Entity Interaction Flowchart

4.6.3 Symptom Handling Program Flowchart

This flowchart shows how the system handles input from patient to when it sends the symptom report to the obstetrician/gynaecologist.

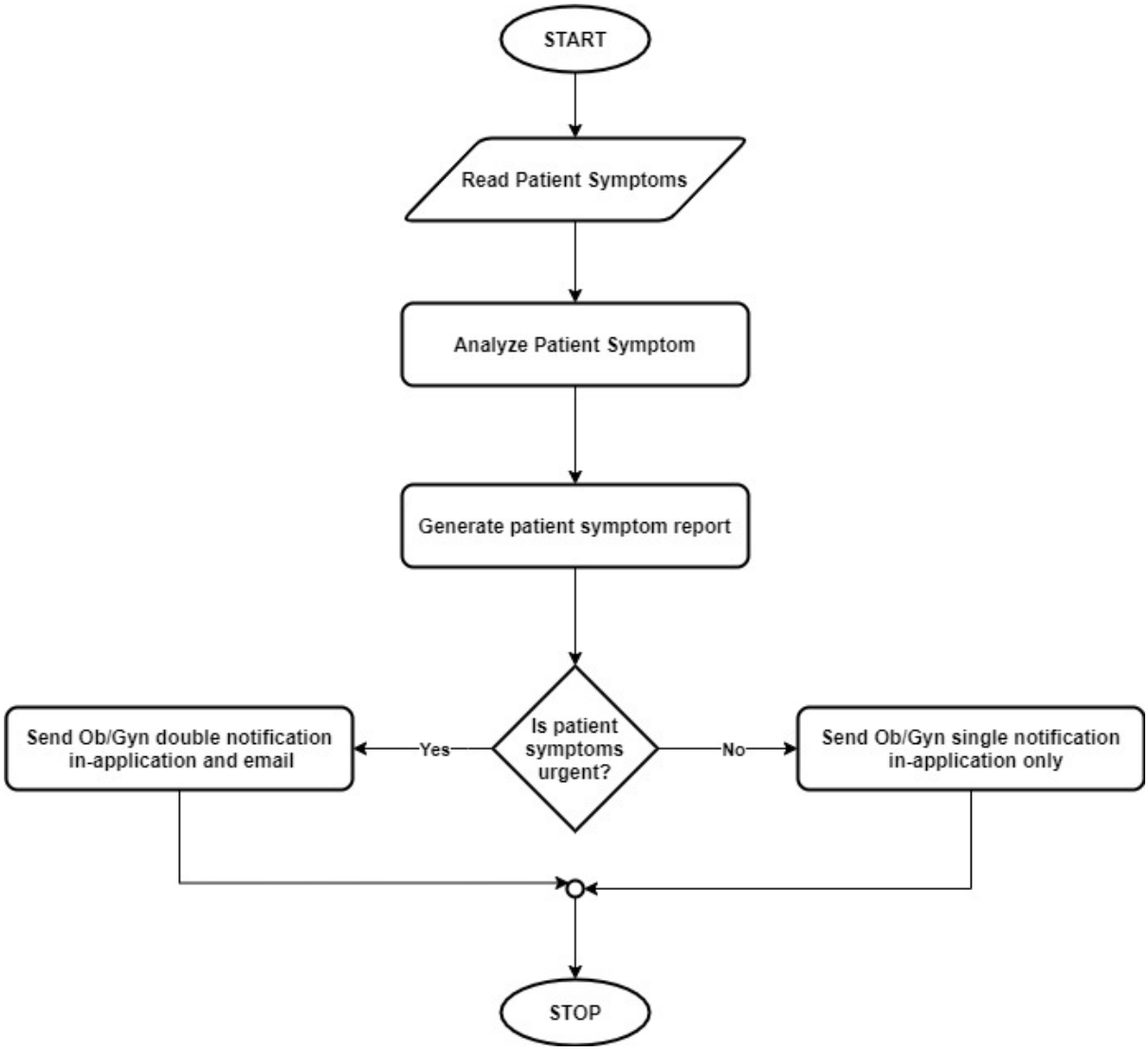

Figure 4.5 Symptom handling flowchart

4.6.4 Diagnosis Handling Program flowchart

This flowchart shows how the obstetrician handles symptom analysis reports input from the system to when he/she finally gives a diagnosis and medical comments for the patient.

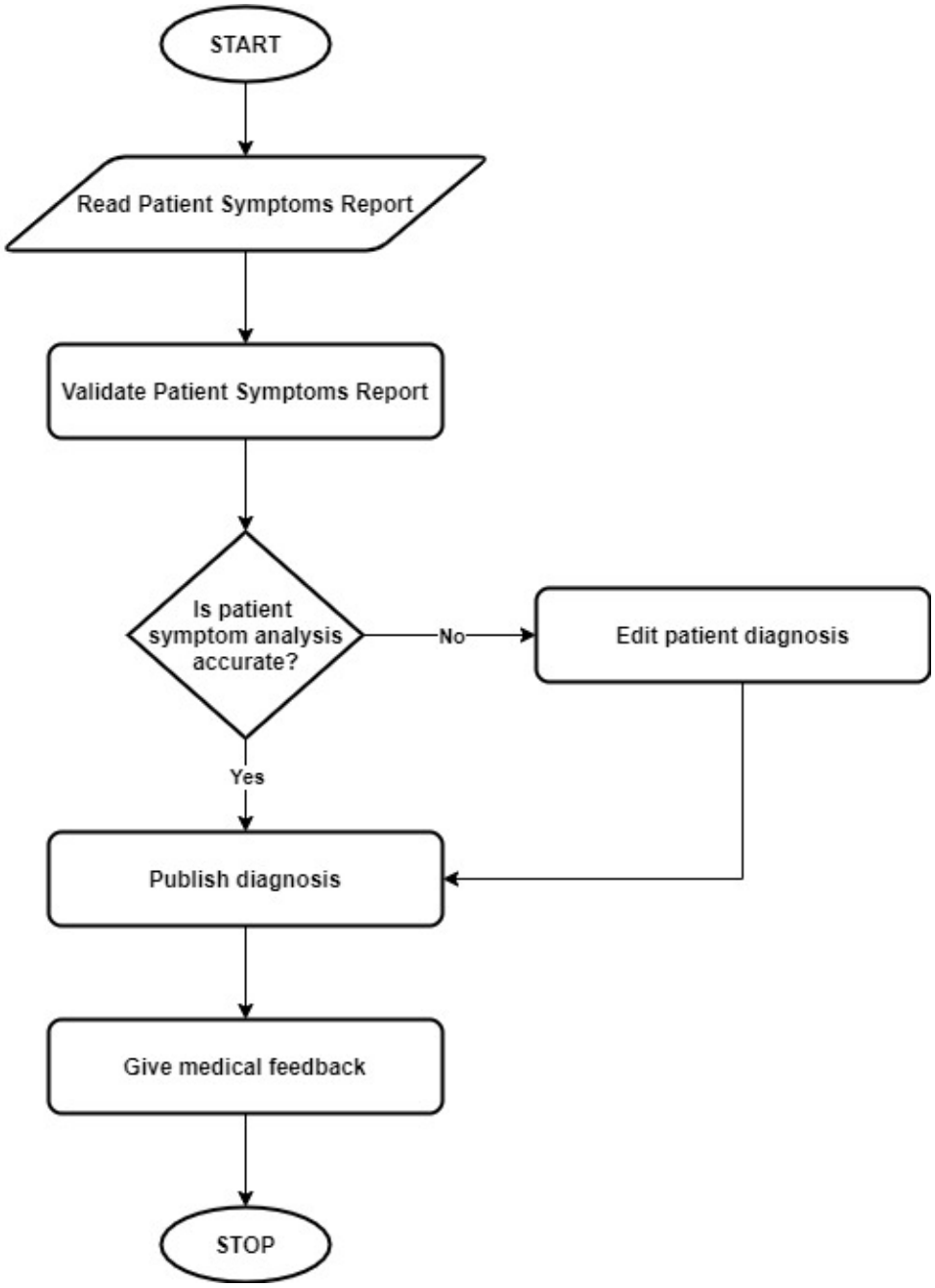

Figure 4.6 Diagnosis handling flowchart

4.6.5 Entity Relationship Diagrams

'An Entity Relationship Diagram (ERD) is a model that shows the logical relationships and interactions among system entities.'(Shelly et al., 2012). An example of entity-relationship is that between the expectant woman and the Ob/Gyn. The ERD was used to provide a visual representation on the entire system blueprint that enabled easy understanding of exact requirements.

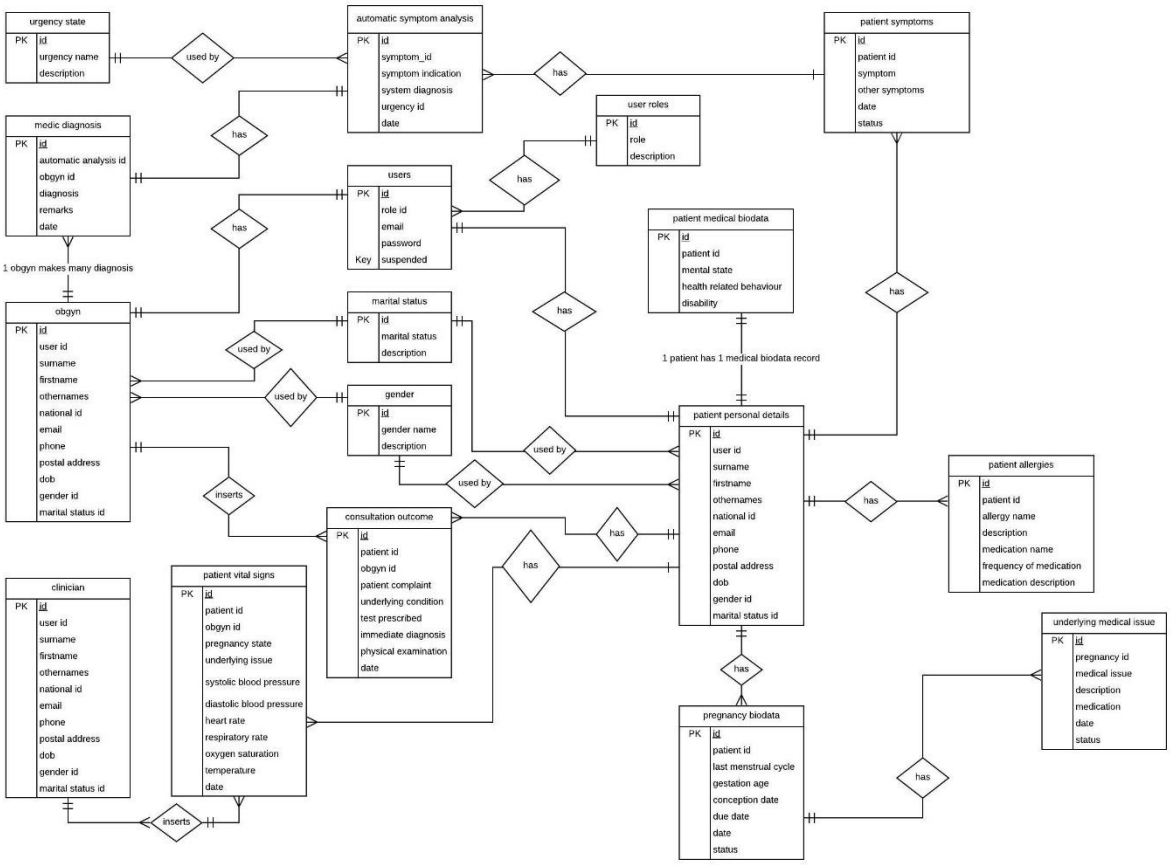

Figure 4.7 Entity Relationship Diagram

4.6.6 Database schema

It is 'the overall description of the database'. (Connolly & Begg, 2015). A database conceptual schema 'describes all entities, attributes and relationships together with integrity constraints'. (Connolly & Begg, 2015) .

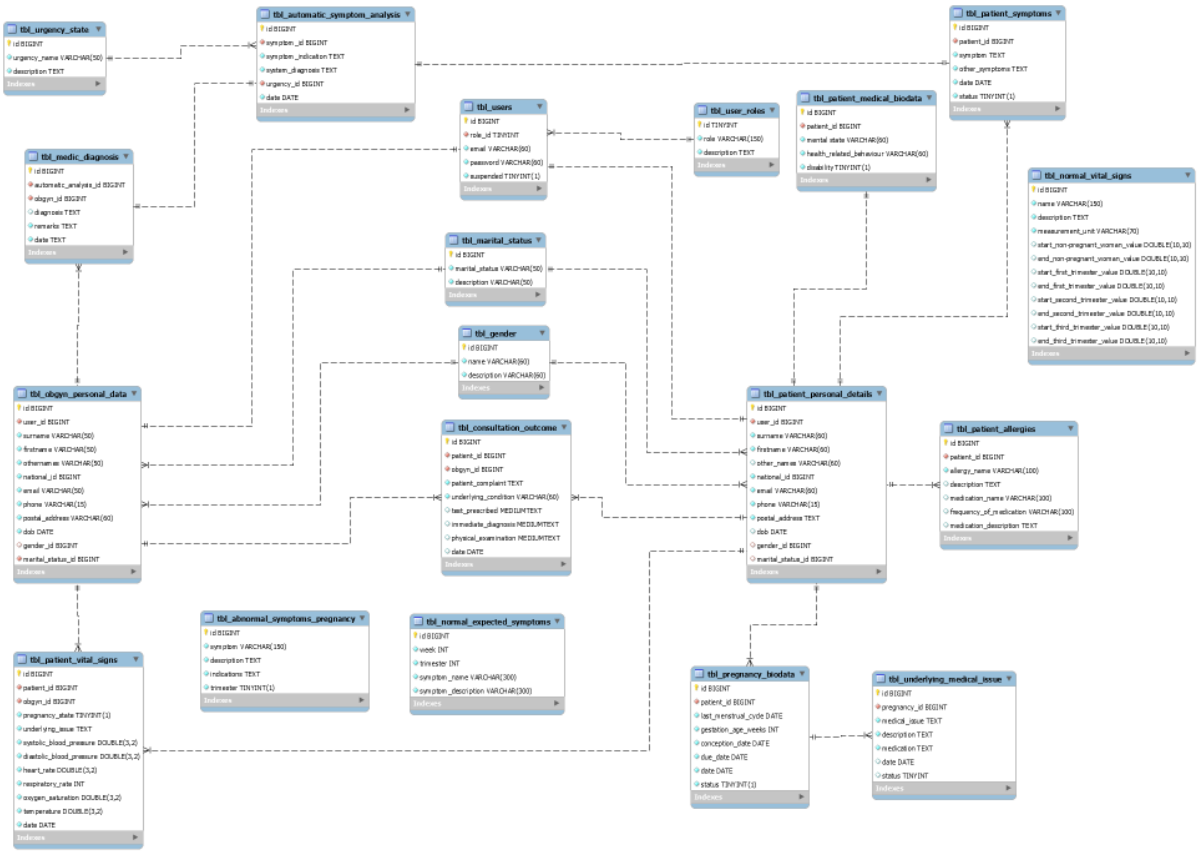

Figure 4.8 Database Schema

Chapter 5: System Implementation and Testing

5.1 Introduction

This chapter focuses on system testing and describing how the system was implemented. Testing is the process of checking if the developed system meets the stated requirements. The Visual Studio Code IDE having a CASE tool, conducted a syntax error test as the code is being typed in real-time.' Desk checking is the process of reviewing the code to spot logical errors that produce incorrect results.' (Shelly et al., 2012) This was done as coding continues and even after coding ended. 'There are four general stages of tests: unit tests, integration tests, systems tests and acceptance tests.' (Dennis et al., 2012). Unit testing involves testing a module to check if it performs a specific function. There is black box and white box testing. 'Black box is a metaphor for actions or processes that produces results in a non-transparent or no-observable manner.' (Shelly et al., 2012). Black box testing was carried out by the users of the system, that is, the expectant women and the Ob/Gyns. The primary goal of black box testing was to establish the working features and those that are not working. 'White-box testing is used when the tester wants to review the actual program code, usually when complexity is high.' (Dennis et al., 2012) White box tests were performed in this developed system by the programmer to check if the system is performing as intended.

Integration tests checks whether the dependent modules of a system work together as expected. It ensures correct links, and the relationships are free of errors. System tests are conducted to see if the entire system is working as expected and if the modules integrate well with all requirements available. Integration tests on the maternal health system were performed to check if the patient and doctor modules work together as expected.

5.2 System Implementation

Identification of system actors – the doctor, patient, clinician, data-manager and administrator. These became modules. I already had a list of everything I required from the requirements analysis phase and therefore it was easy to identify the actors as well as the inputs and outputs of the system.

Creation of database – I created all tables based on diagrams from chapter 4 system design.

Creation of CRUD based pages- For each module I created forms, inserted data into the database, retrieved them from database for reading on screen, then added edit and delete functionality. Retrieval of information from the database had to be specific because every

patient gets to see their own data like gestation age and the symptoms for the particular week of pregnancy they are in.

Creation of main functionality – The main functionality is the Symptom analysis for the patient. From the previous process I already had the input of symptoms. Now I used the Fuzzy Logic Algorithm to analyse the symptoms that the user had input and compare them with the abnormal symptoms available in the database and they were inserted by the data manager. The symptoms get analysed and a report gets sent to a doctor through in-app notification if symptoms do not match any danger symptoms known by the algorithm. If symptoms match danger symptoms, then the notification is through in-app notification as well as email notification to mark it as urgent and make the doctor respond quick in case the symptom poses danger to the patient. I created a medical feedback functionality where the doctor responds to the patient symptom analysis report and it gets displayed to the patient. The patient never gets to see the results of the automatic symptom analysis done by the system because it is not necessary to cause panic to her. Only the doctor gets to see this analysis report and confirm if it is true. If she is seriously sick the doctor decides what course of action to take immediately. Patient then receives doctor's feedback.

Creation of reports – I created reports for retrieving patients with their complications and a report for patients with their vital signs. The vital signs report is classified as either normal or divergent from the expected one can get a report of either of the two separately or as one file. The patient's complications report is classified according to the respective complications they have, similarly, one can get for an individual complication or for all combined complications. I populated the dashboards with summary of the respective modules.

5.3 Test Environment

5.3.1 Hardware Requirements

Hardware	**Hardware description**
Processor	Intel(R) Core(TM) i3-6006U CPU @ 2.00GHz, 2000 MHz, 2 Core(s), 4 Logical Processor(s)
Memory	At least 1GB
Hard Disk space	500MB
Others	Internet access

5.3.2 Software Requirements

Item	Value
OS Name	Microsoft Windows 10 Home Single Language
Version	10.0.17134 Build 17134
Processor	Intel(R) Core(TM) i3-6006U CPU @ 2.00GHz, 2000 MHz, 2 Core(s), 4 Logical Processor(s)
Installed Physical Memory (RAM)	4.00 GB
Resolution	1366 x 768 x 60 hertz
Browser	Google Chrome
System CMOS/real time clock	I/O Port 0x00000070-0x00000070
Relational database management system	MySQL
Programming languages	JavaScript
Integrated Development Environment	Visual Studio Code
Server	Node JS Server

5.4 Test Cases

TEST ID	RELATED REQUIREMENT	INSPECTION CHECK	PRE-CONDITION	TEST DATA	PRIORITY TEST
T1	FR1	Does the system allow the user to self-register?	None	Email: august@gmail.com password: august	Medium
T2	FR2	Does the system allow the clinician to record the medical data of the expectant woman?	None	Email: clinician@gmail.com password: clinician Patient id: 1	High
T3	FR3	Does the system track gestation age of the expectant woman?	The expectant woman should have her pregnancy details recorded by the doctor.	Email: august@gmail.com password: august	High
T4	FR4	Does the system allow the expectant woman to	The expectant woman should have her	Email: august@gmail.com password: august	High

		record her daily symptoms?	pregnancy details recorded by the doctor.		
T5	FR5	Does the system analyse the symptoms recorded by the expectant woman?	The user should have entered extra symptoms other than those provided on expected symptoms.	Email: obstetrician@gmail.com password: obstetrician Patient id: 1	High
T6	FR6	Does the system allow the Ob/Gyn to record the pregnancy data of every expectant woman and record ante natal care on every visit?	The expectant woman must have had her medical data and personal data entered into the system by the clinician	Email: obstetrician@gmail.com password: obstetrician Patient id: 1	High
T7	FR7	Does the system allow the generation of reports with contents of analysed symptoms for every patient?	The expectant woman must have recorded her other symptoms.	Email: obstetrician@gmail.com password: obstetrician Patient id: 1	High
T8	FR8	Does the system allow the Ob/Gyn to record response to the patient symptom report?	The expectant woman must have recorded her other symptoms.	Email: obstetrician@gmail.com password: obstetrician Patient id: 1	High
T9	FR9	Does the system generate a report for the	The expectant woman must have	Email: august@gmail.com password: august	High

		patient with contents of doctor's feedback?	recorded her other symptoms.		
T10	FR10	Does the system generate notifications for both the expectant woman and the Ob/Gyn?	The expectant woman must have recorded her other symptoms.	Email: august@gmail.com password: august Email: obstetrician@gmail.com password: obstetrician	High
T11	FR11	Does the system allow the data manager to manage baseline data for pregnancy?	None	Email: dmanager@gmail.com password: dmanager	High
T12	NFR1	How fast does the system respond to the user?	The system should process data as fast as possible.	Email: dmanager@gmail.com password: dmanager	High
T13	NFR2	Is the system user-friendly?	The system should have informative labels and consistent theme.	Email: august@gmail.com password: august	Medium
T14	NFR3	Can the system run on any web browser?	The system should have been designed with browser compatibility	Email: dmanager@gmail.com password: dmanager	Medium

Table 5.1 Test Cases

5.5 Test Results

TEST ID	EXPECTED RESULT	ACTUAL RESULT	STATUS	REMARKS
T1	The system should allow the user to register with a unique email.	The system allows registration of unique emails,	Pass	The system notifies the user of existing emails.

		denies existing emails.		
T2	The system should allow the management of patient medical data and vital signs.	The system allows management of patient medical data and vital signs.	Pass	Patient medical data and vital signs can be managed.
T3	The system should track gestational age of an expectant woman.	The system allows tracking of gestational age of an expectant woman.	Pass	The system calculates gestation age daily.
T4	The system should allow the expectant woman to record her daily symptoms.	The system allows the expectant woman to record her daily symptoms.	Pass	The system records the daily symptoms.
T5	The system should analyse the symptoms recorded by the expectant woman.	The system analyses the symptoms recorded by the expectant woman.	Pass	The system analyses the symptoms recorded by the expectant woman.
T6	system should allow the Ob/Gyn to record the pregnancy biodata of every expectant woman and record ante natal care on every visit.	system allows the Ob/Gyn to record the pregnancy biodata of every expectant woman and record ante natal care on every visit.	Pass	system allows recording of pregnancy biodata.
T7	system should be able to generate a report with contents of analysed symptoms for the Ob/Gyn.	System generates report for patient symptoms.	Pass	Report generation successful.
T8	system should allow the Ob/Gyn to record response	System allows response recording by Ob/Gyn.	Pass	Medical response recording successful.

	to the symptom reports.			
T9	system should generate a report with contents of Ob/Gyn feedback for the expectant woman.	System generates reports for patient after Ob/Gyn feedback.	Pass	Report generation successful.
T10	system should generate notifications for both the expectant woman and the Ob/Gyn.	System generates notifications for both users.	Pass	Notification generation successful.
T11	system should allow the data manager to create, update and delete the baseline information of pregnancy.	System allows management of pregnancy baseline information	Pass	Pregnancy Information Data management successful.
T12	The system should respond to the user as fast as possible	The system responds as soon as the processing is complete.	Pass	The system response is fast.
T13	The system should be user-friendly.	The system is user friendly with informative labels and consistent User Interface.	Pass	The system is user-friendly.
T14	The system should run on any web browser.	The system runs on Google Chrome, Microsoft Edge and Mozilla Firefox.	Pass	The system is browser compatible for the most preferred browsers.

Table 5.2 Test Results

Chapter 6: Conclusions, Recommendations and Future Works

6.1 Conclusion

The main objective of this system was to develop a maternal health system that would assist in reducing the prevalence of pregnancy related complications through timely signal of abnormal symptoms. Currently the pregnancy process is being tracked by the hospitals through ante natal care visits which may be 7 or more depending on hospital and patients' overall health. There is need to monitor the pregnancy symptoms daily which is not feasible through hospital visits, therefore monitoring them via an application is feasible and would assist in timely signal of abnormal symptoms. This is where this maternal health application comes in handy as the expectant woman records her symptoms daily and can get a doctor's review of her symptoms and even when the symptoms get flagged as urgent by the system the doctor would get an email notification and therefore respond to the case with the urgency it requires. It is worth noting that this developed system does not serve to replace the current system of hospital visits, but it rather comes as a supplementary to cover for the days that the patient is not going for her clinical visits. In conclusion pregnancy complications can be made less prevalent by early detection.

6.2 Recommendations

The maternal health application requires that doctor would respond to the symptoms on time especially the ones notified by email because those are the ones with a high priority. It would be recommended that the expectant woman is able to stick with one maternal hospital through out the gestation period for the purposes of consistency in recording of ante natal health data.

6.3 Future Works

The maternal health research is a very expansive and there is still more research that could be done. For instance, the patients could be allowed to record their vital signs from home if they have gadgets like blood pressure sphygmomanometer or temperature thermometer and it directly integrates with the hospital system and data gets updated. This would be particularly helpful for women with underlying conditions like hypertension since they need their blood pressure monitored through out the day especially in pregnancy. It would also be great of the application could allow patients to interact with other patients so that they can talk about their pregnancy journeys and peer-learn from each other.

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A. Appendix

Application Screenshots

Figure A. 9 Register

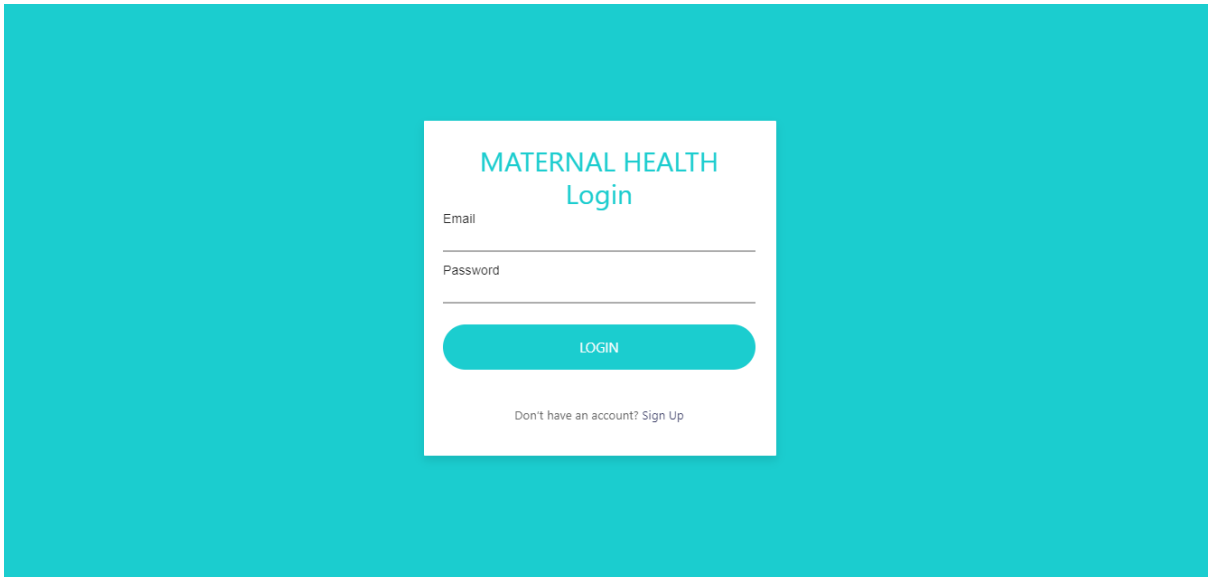


Figure A. 10 Login

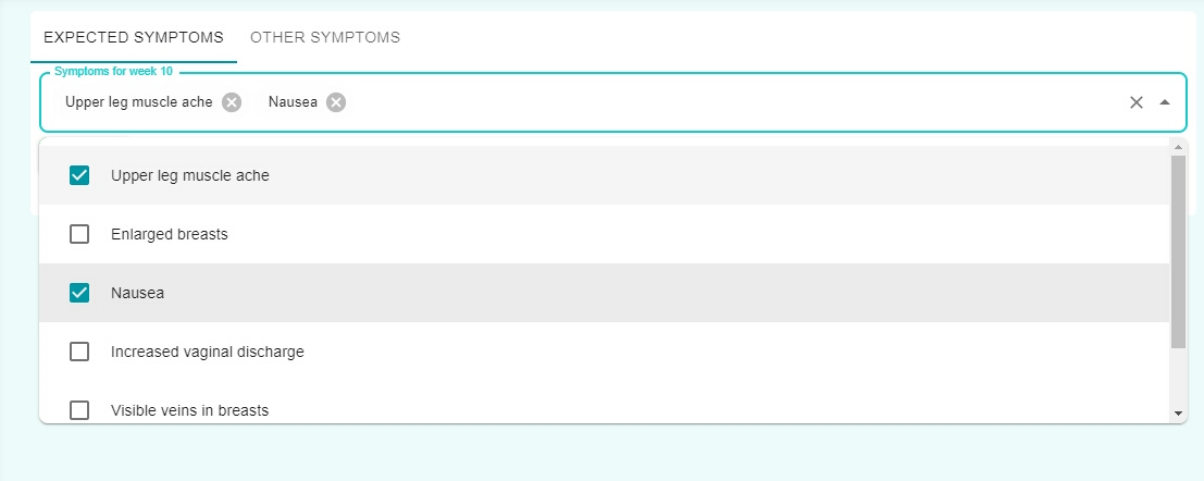


Figure A. 11 Patient Input of Expected symptoms

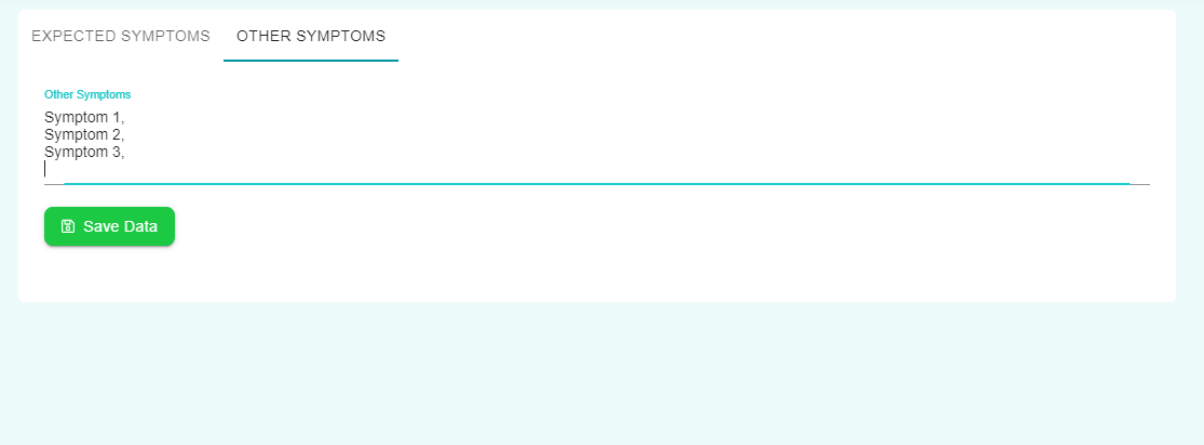


Figure A. 12 Patient Input of other symptoms

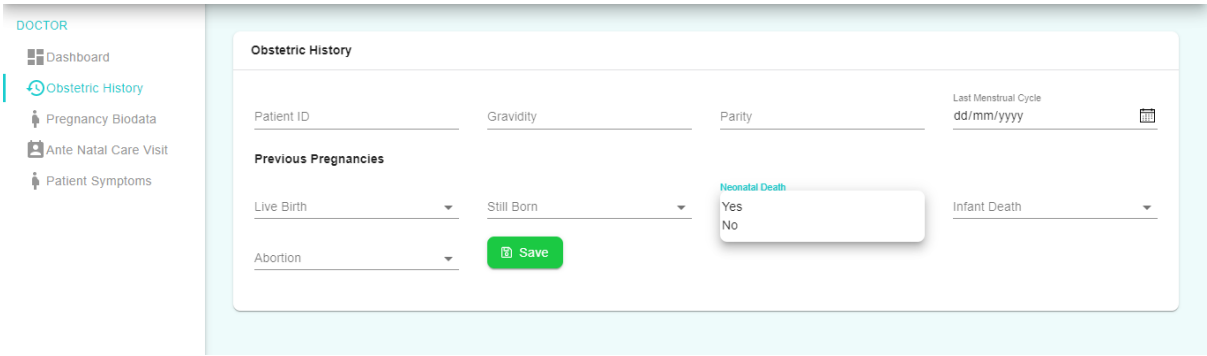


Figure A. 13 Doctor Input of Obstetric History

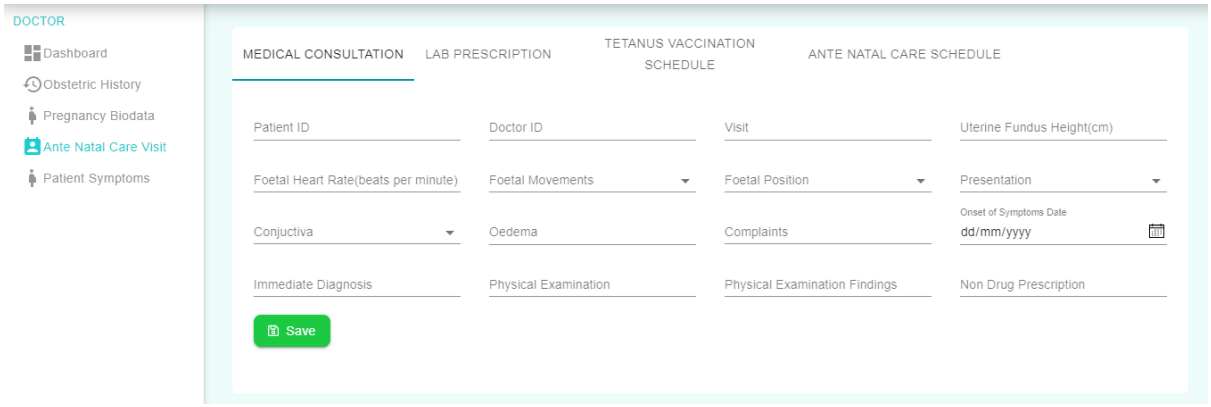


Figure A. 14 Doctor Input of Medical Consultation

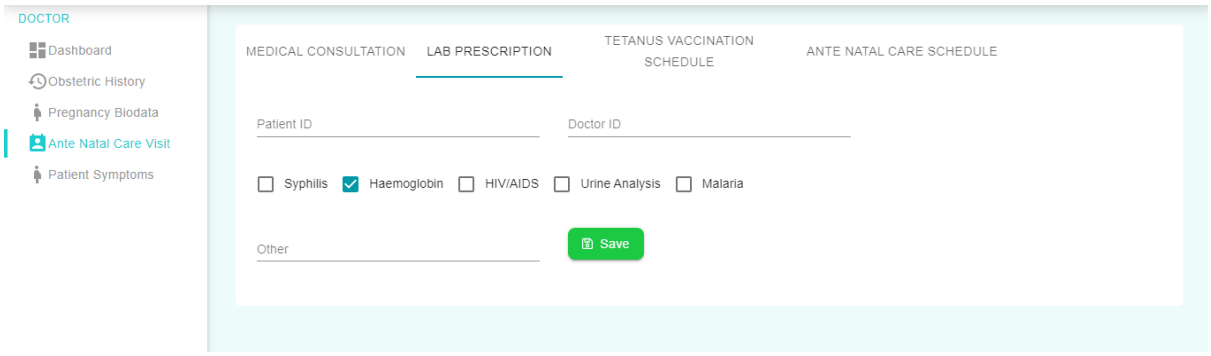


Figure A. 15 Doctor Lab prescription

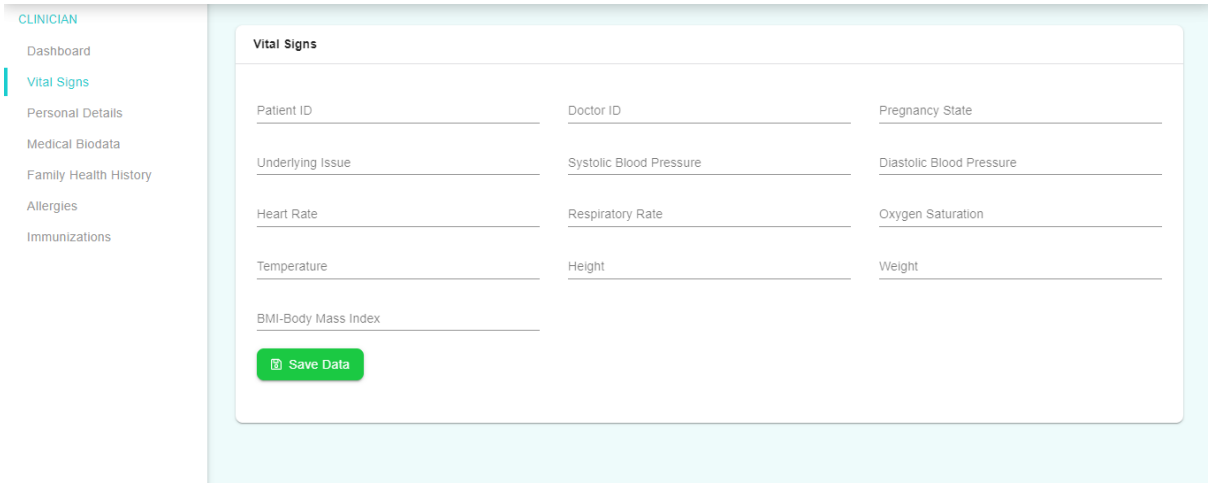


Figure A. 16 Clinician Input of vital signs

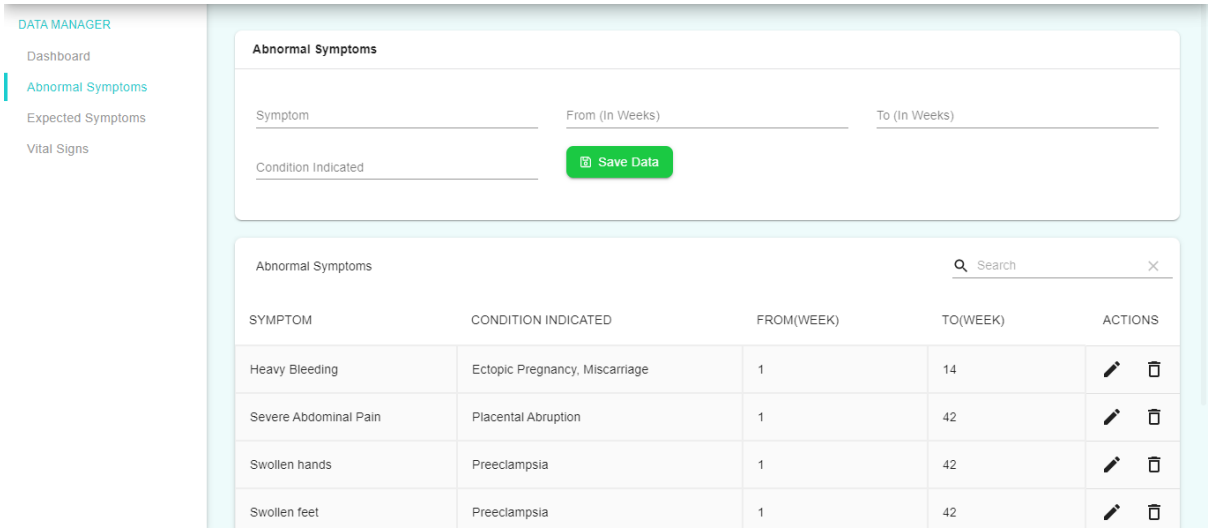


Figure A. 17 Data manager Entry of abnormal symptoms baseline data

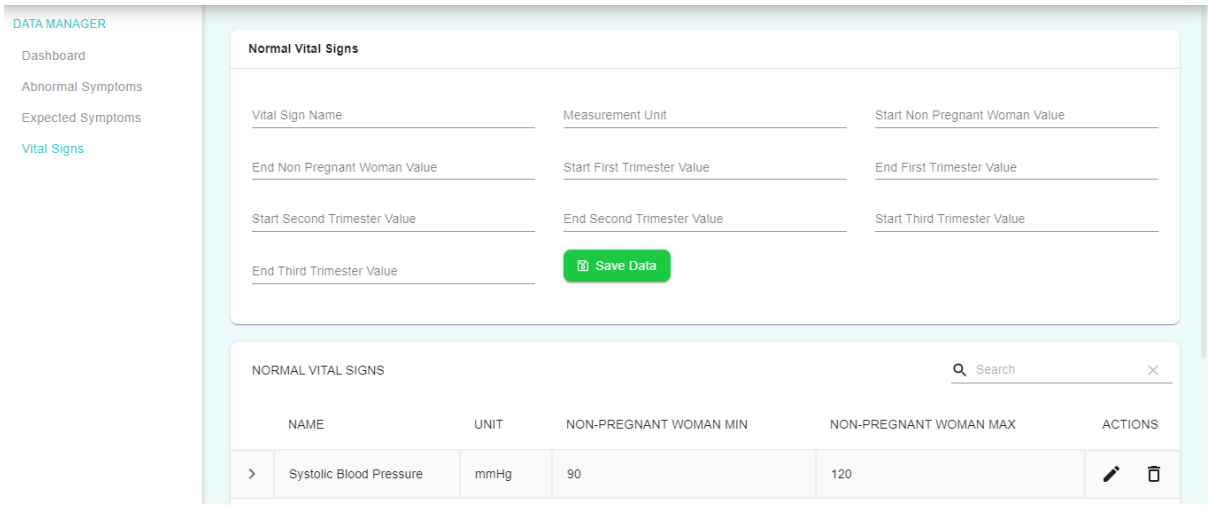


Figure A. 18 data manager entry of vital signs baseline data

B. Appendix

Interesting Code

This is securing the application using password encryption bycrypt js.

```
var jwt = require("jsonwebtoken");
var bcrypt = require("bcryptjs");

exports.signup = (req, res) => {
  // Save User to Database
  User.create({
    email: req.body.email,
    password: bcrypt.hashSync(req.body.password, 8)
  })
    .then(user => {
      if (req.body.roles) {
        Role.findAll({
          where: {
            name: {
              [Op.or]: req.body.roles
            }
          }
        }).then(roles => {
          user.setRoles(roles).then(() => {
            res.send({ message: "User registered successfully!" });
          });
        });
      } else {
        // user role = 1
        user.setRoles([1]).then(() => {
          res.send({ message: "User registered successfully!" });
        });
      }
    })
    .catch(err => {
      res.status(500).send({ message: err.message });
```

Figure B. 3 Password hashing

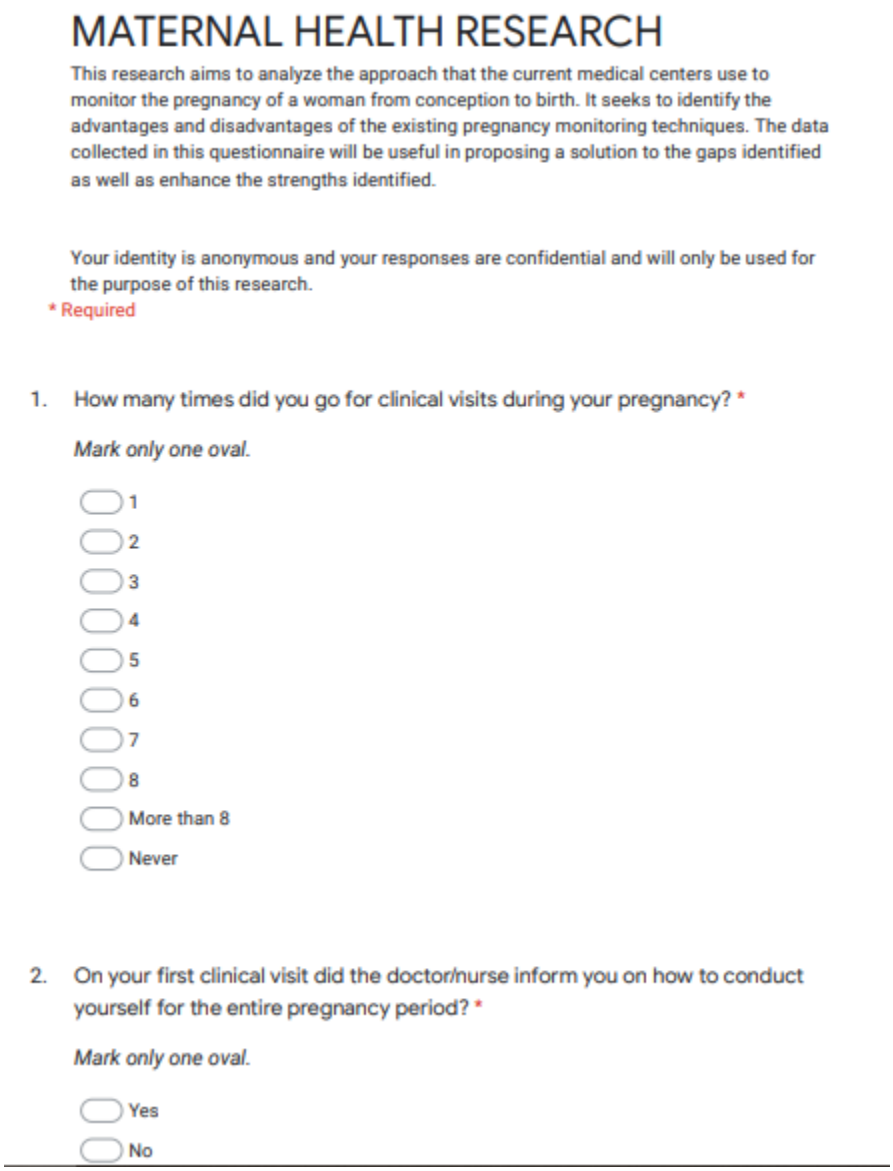
This is the main functionality that is used for checking if patient input symptoms are dangerous or not. Dangerous symptoms are flagged if they match what exists in the database.

```
//symptom analysis using fuzzy logic algorithm
const options = {
    isCaseSensitive: false,
    includeScore: false,
    shouldSort: true,
    includeMatches: false,
    findAllMatches: false,
    minMatchCharLength: 4,
    location: 0,
    threshold: 0.6,
    distance: 100,
    useExtendedSearch: false,
    ignoreLocation: false,
    ignoreFieldNorm: false,
    keys: [
      'symptom',
      'from_week',
      'to_week',
      'condition_indicated'
    ]
};
const fuse = new Fuse(abnormal_symptoms, options);
// Search
const result = fuse.search(other_symptom);
```

Figure B. 4 Fuzzy logic Algorithm

C. Appendix

Questionnaire for acquiring user requirements



MATERNAL HEALTH RESEARCH

This research aims to analyze the approach that the current medical centers use to monitor the pregnancy of a woman from conception to birth. It seeks to identify the advantages and disadvantages of the existing pregnancy monitoring techniques. The data collected in this questionnaire will be useful in proposing a solution to the gaps identified as well as enhance the strengths identified.

Your identity is anonymous and your responses are confidential and will only be used for the purpose of this research.

* Required

1. How many times did you go for clinical visits during your pregnancy? *

Mark only one oval.

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- More than 8
- Never

2. On your first clinical visit did the doctor/nurse inform you on how to conduct yourself for the entire pregnancy period? *

Mark only one oval.

- Yes
- No

Figure C. 6 Questionnaire part 1

3. What medical tests did they perform on you that are mandatory to all pregnant women? *

4. Did the medical center inform you on how to respond to an emergency situation in regard to your pregnancy? *

Mark only one oval.

- ◯ Yes
- ◯ No

5. How were you responding to major symptoms for example severe abdominal pains or bleeding? *

Check all that apply.

- ☐ I visited a medical center
- ☐ I took over the counter drugs
- ☐ I Aasked a doctor/nurse about it immediately
- ☐ I asked a woman who has been pregnant and experienced such symptom before.
- ☐ I did not have any major symptoms

Other: ☐

Figure C. 7 Questionnaire part 2

6. How were you responding to minor symptoms for example headache or fatigue? *

Check all that apply.

- [ ] I visited medical center
- [ ] I took over the counter drugs
- [ ] I asked a doctor/nurse about it immediately
- [ ] I waited for my clinic visit to ask the doctor about it.
- [ ] I asked a woman who has been pregnant and experienced such symptom before.

Other: [ ] _____

7. How did you know if a symptom was a bad sign or if it was just a normal pregnancy symptom? *

Check all that apply.

- [ ] I contacted the doctor to know.
- [ ] I visited the medical center to know.
- [ ] I was given information by the medical center beforehand on what to expect.
- [ ] I did my own research and got information from the internet.
- [ ] I asked friends and family.
- [ ] I judged based on the amount of discomfort I felt.
- [ ] I did not have any symptoms.

Other: [ ] _____

8. Other than the clinical visits , did you visit a medical center or had contact with a doctor to discuss the progress in your pregnancy so far? *

Mark only one oval.

- ◯ Yes
- ◯ No

Figure C. 8 Questionnaire part 3

9. Did you develop any pregnancy related complications? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Other: _____

10. If you answered yes above, how many days did it take for you to get a medical diagnosis since the day you started having a symptom of the complication?

Check all that apply.

- ☐ The same day
- ☐ 1 day
- ☐ 2 days
- ☐ 3 days
- ☐ 7 days
- Other: ☐ _____

11. If you had a pregnancy complication was it preventable?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ I don't know
- ◯ Other: _____

Figure C. 9 Questionnaire part 4

12. What did you like about how the medical center handled your pregnancy from conception to birth? *

13. What did you dislike about how the medical center handled your pregnancy from conception to birth? *

14. What would you like improved in how the hospital handled your pregnancy from conception to birth? *

15. What do you wish you had known sooner that would have made your pregnancy journey better? *

Figure C. 10 Questionnaire part 5

D. Appendix

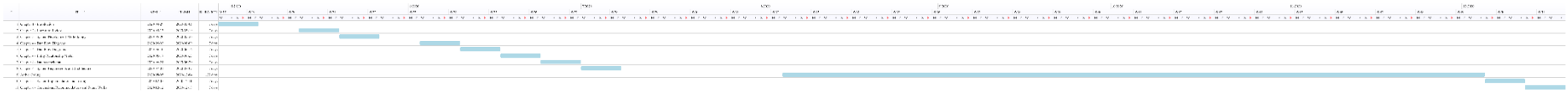


Figure D. 2 Gantt Chart