INFORMATION SYSTEM FOR MONITORING VACCINATIONS IN EXPECTANT PREGNANT MOTHERS AND CHILDREN UNDER FIVE YEARS: A CASE STUDY: RBC-RWANDA

By

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Thesis Submitted in Partial Fulfillment of the Requirements for the Award of Master's Degree in Internet Systems (MIS)

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DECLARATION

I; **Scovia MUKANSANGA**, hereby declare that this research study entitled **"INFORMATION SYSTEM FOR MONITORING VACCINATIONS IN EXPECTANT PREGNANT MOTHERS AND CHILDREN UNDER FIVE YEARS"** submitted in partial fulfilment of the requirement for the award of the Degree of Master of Internet Systems. I declare that the work reported in this study is my original work and has not been presented to any other Institution. No part of this research should be reproduced without the authors' consent or that of Kigali Independent University.

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CERTIFICATION

This is to certify that the study entitled **"INFORMATION SYSTEM FOR VACCINATION MONITORING IN EXPECTANT PREGNANT MOTHERS AND CHILDREN UNDER FIVE YEARS"** submitted by Scovia MUKANSANGA, Roll number: MSIS-202111004 to the Kigali Independent University in partial fulfilment of the requirement for the award of Master's Degree in Internet System.

Supervisor: Dr. HABIMANA Olivier

Date: …..... /...../……

Signature ……

DEDICATION

I dedicate this work to my beloved relatives, my father, my mother and my brother BISANGWA among others, for the continued moral and financial support, sincere guidance, and encouragement they have rendered to me throughout my education.

May the Almighty God reward them abundantly.

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I am grateful to Almighty God for His endless care, abundant blessings, and provision of good health throughout undertaking my studies. I would like to express sincere thanks to my supervisor, Dr. HABIMANA Olivier, for his professionalism and continuous suggestions that inspired and encouraged me to work hard throughout the process of this study. Finally, I thank my family for being there for me every step of the way. It has always made everything so easy, reachable, and possible that I never felt lonely or struggled.

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LIST OF ABBREVIATIONS AND ACRONYMS

ISMV : Information System for Monitoring Vaccinations

BCG : Bacillus Calmette Guérin Vaccination

CDC : Centers for Disease Control and Prevention

CHWs : Community Health Workers

CSS : Cascading Style Sheets

DD : Data Dictionary

DFD : Data Flow Diagrams

DTP-HepB-Hib: Diphteria, Tetanus, Pertussis, HepatitisB and HemophilusInfluenza

ERD : Entity Relationship Diagram

HTML : Hyper Text Markup Language

ICT : Information and Communication Technology

IPV : Inactivated Polio Vaccine

MDGs : Millennium Development Goals

MMCH : Monitor the Quality of Maternal and Child Healthcare,

MMR : Maternal Mortality Ratio

OPV : Oral Polio Vaccine

PCV13 : Pneumococcal vaccine

PDM : Physical Data Model

PHP : Hypertext Pre-processor

RAM : Random Access Memory

RBC : Rwanda Biomedical Centre

RDBMS : Relational Database Management System

RGB : Rwanda Governance Board

UML : Unified Modeling Language

UN : United Nations

USA : United States of America.

VIS : Vaccination Information System

VPDD : Vaccine Preventable Diseases Division

VTIS : Vaccination Tracking Information System

WHO : World Health Organization

ABSTRACT

Vaccination is the way of prevention from various infectious diseases, in many countries the process of Vaccinations system is not technology based. In Rwanda patients (child and pregnant woman) use manual Vaccination system still now which is not secure. The existing systems are the paper-based system therefore peoples are going to be digitalized on their particular life in Rwanda. each of both category of patients wants secured and flexible vaccination tracking Information system than the existing manual system, the management of all childhood and motherhood vaccination services relied on the use of vaccination cards to track vaccines received and set the appointments for future vaccination dates also on paper. This information was manually recorded for reporting purposes and program monitoring which is time consuming for both vaccination Department in RBC and Patients. Vaccination Tracking Information system can solve many problems to monitor and maintain proper vaccination system especially problem of an unaware mother at third world country and child health about vaccination service.

Information System for Monitoring Vaccinations (ISMV) is web-based system, the methodology used includes primary and secondary data collection, interviews, questionnaires and documentation. In addition, several technologies were also used to develop the system, such as HTML, CSS, JavaScript as Front-end languages, PHP as Server-side languages, MySQL as Database and PhpMyAdmin, Apache as Database GUI tools. Furthermore, the research design and implementation of the prototype of Vaccination Tracking Information System allow the system admin to register Nurses in order to gain credentials on the system for the treatment of children under five years and pregnant mothers in vaccination services. This research contributes to the development and implementation of ISVM which improves the management and the security of the patients which request vaccinations services at health center. During the production phase of ISVM, this system will be integrated with some telecommunication company in Rwanda like MTN Rwanda for sending appointment notification to the patient who request the vaccination service. The system provides an effective way for administrators to view the dashboard, a graphical user interface. System updates dynamically the time and dates based on when an individual vaccinated and given appointment.

Keywords: Child Vaccination, Pregnant mother vaccination, Information System for Vaccination monitoring, Manual system, Data Security.

CHAPTER ONE: GENERAL INTRODUCTION TO THE STUDY

1.0 Introduction

This chapter contains the background of the study, statement of the problem with clear purpose of the study, objectives as well as research questions, scope of study as well as significance of study, Definitions of Key Concepts, Structure of the thesis.

Vaccines are the first step of preventing diseases including polio, whooping cough, diphtheria, measles, rubella (German measles), mumps, Haemophilus influenza type b (Hib) and tetanus. The Vaccine helps to protect infants, children and even adults from infections and premature death caused by many infectious diseases. The dosage of vaccination remains the same among babies and pregnant mothers but may be different for adults. Modern health technology plays an important role in the improvement of vaccination. There are a lot of problems parents are faced in the manual system like uncertainty, data loss, and misconduct, lack of efficiency, dishonesty, unawareness, and insecurity. All of these problems are a major threat for vaccination system and also for patients (pregnant mothers and children). (by Paul Thomas, M.D., and Jennifer Margulis, Ph.D., 2021)

Vaccinations for children and pregnant mothers form a crucial part of public health initiatives. Local healthcare providers work closely with families to ensure children receive their recommended vaccines at the appropriate ages.

On a global scale, organizations such as the World Health Organization (WHO) and UNICEF work tirelessly to promote vaccination as a fundamental human right. They support countries in developing comprehensive immunization strategies, ensuring that even in remote areas, pregnant mothers and children have access to life-saving vaccines. Worldwide efforts focus not only on the availability of vaccines but also on education, addressing vaccine hesitancy, and establishing sustainable immunization infrastructures. Therefore, vaccinations for children and pregnant mothers are cornerstones of public health initiatives at the local, regional, and global levels. By ensuring access to vaccines, providing education, and addressing concerns, communities and nations can create healthier environments for future generations, protecting lives and promoting overall well-being. (by Adam Kucharski , 2020).

1.1 Background to the Study

Rwanda has taken a big step in terms of vaccination; prevention of diseases preventable by vaccination is one of priorities set by Rwanda government in order to gradually reduce infant and child mortality. Vaccination agendas are among the most cost-effective health interventions and a proven tool for preventing and eradicating disease in worldwide. Certain vaccines are safe and recommended for women before, during, and after pregnancy to help keep them and their babies healthy. The antibodies mothers develop in response to these vaccines not only protect them, but also cross the placenta and help protect their babies from serious diseases early in life (WHO, 2018).

The U.S. Centers for Disease Control and Prevention recommend that pregnant persons receive several vaccinations during pregnancy to help protect infants. Maternal immunization provides important protections in the first few months of life before infants are eligible to receive their first vaccines. Some of the countries all over the world are still struggling with getting the sufficient information related to vaccination for pregnant mothers and children under five years as source of maternal deaths and infant mortality. In USA, more than 1,200 U.S. women died in 2021 during pregnancy or shortly after childbirth, according to a final tally released Thursday by the Centers for Disease Control and Prevention. In 2022, there were 733 maternal deaths, according to preliminary agency data, though the final number is likely to be higher (Masud T, and Navaratne KV. , 2023).

According to (Shaikh BT, and Alizai AA., 2022), in UK, Comparison of the two periods showed a slight increase in the overall maternal death rate, from 10.9 per 100 000 maternities (pregnancies that ended in childbirth or stillbirth) in 2018-20 to 11.56 per 100 000 in 2019-21. In France, the infant mortality rate for France in 2022 was 2.748 deaths per 1000 live births, a 2.52% decline from 2021. The infant mortality rate for France in 2021 was 2.819 deaths per 1000 live births, a 2.46% decline from 2020. In China, the country's maternal death rate dropped from 43.2 per 100,000 in 2002 to 15.7 per 100,000 in 2022, while infant mortality declined from 37.6 per 1,000 in the early days of reform and opening-up to 4.9 per 1,000. In Japan, 4 women die per 100,000 live births due to pregnancy-related causes in Japan. The maternal mortality ratio in Japan has remained stagnant over the last 20 years roughly around 4. Maternal mortality in Japan is lower than its regional average. In Russia, the maternal mortality rate in 2022 amounted to 13 deaths per 100 thousand live births, thus marking a

considerable decrease from the previous year when it was measured at 34.5 deaths per 100 thousand live births (Shaikh BT, and Alizai AA., 2022).

In Sub-Saharan Africa Countries, the maternal mortality ratio in 2020 was estimated at 531 deaths per 100 000 live births. Countries with extremely high maternal mortality rates are South Sudan with 1223 deaths, followed by Chad with 1063 deaths and Nigeria with 1047 deaths per 100 000 live births. In the East African region, the overall MMR decreased from 853 to 443 maternal death per 100,000 births. In Tanzania, the Tanzania recorded 119 maternal deaths, this declined to 75 in 2021 and subsequently increased to 102 in 2022, Subsequently, 127 perinatal deaths were recorded in 2021 and as of 31st May 2023, already 26 women have died while giving birth, and 289 newborns died due to pregnancy-related complications (Scott C, Clarke K, Grevendonk J, et al., 2023).

In Rwanda, maternal mortality ratio is the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births. The data are estimated with a regression model using information on the proportion of maternal deaths among non-AIDS deaths in women ages 15-49, fertility, birth attendants, and GDP. Rwanda maternal mortality rate for 2020 was 259.00, a 7.83% decline from 2019.Rwanda maternal mortality rate for 2019 was 281.00, a 0% increase from 2018. Rwanda maternal mortality rate for 2018 was 281.00, a 2.18% increase from 2017. Rwanda maternal mortality rate for 2017 was 275.00, a 5.82% decline from 2016 (World Bank, 2023).

RBC Rwanda will benefit to the Vaccination Tracking Information System for pregnant women and children against tetanus, diphtheria, influenza and more diseases have generated important lessons and helped to establish the practices and knowing information that help in future planning in health sector especially for pregnant mother and child. A vaccine is a medicine that helps to protect people from certain diseases. During pregnancy, vaccinations help to protect both mother and her baby. Some of Vaccines taken by pregnant women during the pregnancy are two types of vaccines which are inactivated influenza at 3moths of pregnancy; Tdap which composed by Tetanus toxoid, reduced diphtheria toxoid and acellular pertussis (Tdap); plus, COVID_19 vaccines if does not taken. Also, there are vaccines intended to children from their birth to five years' old which are the Bacillus Calmette-Guérin (BCG) vaccination) at the birth given to new born babies at risk of getting tuberculosis (TB). TB is a very serious infectious disease that can cause TB meningitis in babies and Oral Polio at the

birth for protecting against the poliovirus which is a highly infectious disease that invades the nervous system and can lead to total paralysis. The virus primarily affects children 5 years and below. (Apollo Specialty Hospitals Private Limited, 2023).

At six weeks (6 weeks) baby also should take Oral Polio Vaccine (OPV), Diphteria, Tetanus, Pertussis, HepatitisB and HemophilusInfluenza (DTP-HepB-Hib), Pneumococcal vaccine (PCV13) and Rotavirus (Rotarix) whereby DTP-HepB-Hib helps to protect the child against: diphtheria, tetanus, pertussis (whooping cough), polio, Haemophilus influenzae type b (Hib), hepatitis B and PCV13 protects against 13 of the approximately 90 types of pneumococcal bacteria that can cause pneumococcal disease, including pneumonia, meningitis, and bacteremia. Rotarix to protect against rotavirus disease that can be spread easily among infants and young children. The virus can cause severe watery diarrhea, vomiting, fever, and abdominal pain. At ten weeks (10 weeks) child should take also Oral Polio Vaccine (OPV) Diphteria, Tetanus, Pertussis, Hepatitis B and Hemophilus Influenza (DTP-HepB-Hib) Pneumococcal vaccine (PCV13) and Rotavirus (Rotarix).

At fourteen weeks from the birth, a child should also take Oral Polio Vaccine (OPV), Inactivated Polio Vaccine (IPV), Diphteria, Tetanus, Pertussis, Hepatitis B and Hemophilus Influenza (DTP-HepB-Hib) Pneumococcal vaccine (PCV13) whereby Inactivated Polio Vaccine (IPV) for protecting against polio, or poliomyelitis, as part of the series of routine childhood vaccines and provides serum immunity to all three types of poliovirus, resulting in protection against paralytic poliomyelitis. At nine months (36 weeks) a child should take a vaccine of Measles-Rubella (MR) to protect child against measles, mumps, and rubella, Children should get two doses of MMR vaccine, starting with the first dose at 9 months and second dose at 15 months of age (60 weeks), and the second dose. At 6-12 months apart, two doses of the HPV (Human papillomavirus) shot are needed for protect child from HPV infections that can cause cancer later in life as well as genital warts. It can spread through sex and from some types of skin-to skin-contact. HPV also can lead to cancer in areas such as the penis, anus, vagina, vulva, and throat. Recent research suggests it might be linked to cardiovascular disease in women. (RBC RWANDA, 2022).

Rwanda Biomedical Center (RBC) gathering different programs which include one division that focus on vaccinations called Vaccine Preventable Diseases Division (VPDD). The overall goal of the national VPDD is to contribute to the improved well-being of the Rwandan people

through reduction of child morbidity and mortality due to vaccine-preventable diseases. It is comprised of three principal components: routine vaccination, supplemental immunization activities, and surveillance for target diseases. RGB in its report of 2018, ranked vaccination program in Rwanda among the best programs of the health sector whereby vaccination program in Rwanda is offering 13 antigens to a very big number of children, adolescent girls, pregnant women and general population who need adulthood vaccines.

In Rwanda, according to (Sheila McGreevy et al., 2023); Rapid SMS Rwanda is an innovative mobile technology tool that saves lives by tracking pregnant women, newborns and children under two years of age at community and health facilities that receives reports on key MNCH indicators from over 45,000 community Health Workers (CHWs) in 15,000 villages across Rwanda. The Rapid SMS-MCH system was designed to provide an SMS-based platform, enabling effective and real-time two-way communication for action, between CHWs at community level, and the rest of the health system (ambulance, health facility staff, District Hospital and Central level) through mobile phones. The primary expected result of the system is an improved access to antenatal, postnatal care, institutional delivery, and emergency obstetric care and RED ALERT emergency response system on real time Rapid SMS provides a database for keeping clinical records of maternal, Newborn and Child care delivery.

Rapid SMS technology receives short messages (SMS) from CHWs and sends a short feedback message to a centralized computer which is able monitor incoming information about emergencies (red alerts) and high-risk cases in real time, and provides a reminder when follow up care is required. RapidSMS is one of strategies that Rwanda has employed in the effort to reduce maternal and child death. The platform was implemented to facilitate communication between CHWs and the ambulance system, health facilities staff, and the central government. CHWs are the lowest level of service delivery at the community level, offer preventive and basic curative services at village level, transmit key MNCH indicators to the system directly.

1.2 Problem Statement

For making sure mother's vaccinations are current before she gets pregnant, there is an urgent need for active safety surveillance to monitor vaccine exposure during pregnancy in low- and middle-income countries like Rwanda. Existing maternal, newborn, and child health data collection systems serve as platforms for active surveillance of maternal immunization safety

(Levin A, & Kaddar M., 2021). The management of all childhood vaccination services relied on the use of vaccination cards to track vaccines received and set the appointments for future vaccination dates also on paper. This information was manually recorded for reporting purposes and program monitoring, with appointment reminders handled through phone calls from community health workers to parents where it is possible. Reminders were through phone calls to CWHs to inform parents with children who missed out the appointment. This system was slow. While 98% of all children in Rwanda are born in health facilities, birth notification/registration rarely was reported within the 14-day.

Despite Rwanda is recorded as among the few countries in the region which meet Millennium Development Goals (MDGs) that targets for maternal health and children, there are different challenges like difficult in getting sufficient information to vaccinated pregnant women and children under five years, insufficient research on the safety and efficacy in pregnant women; difficulties in estimating denominators for vaccination coverage in pregnant women; insufficient training of residents on immunization, compared to pediatricians; the inadequate communication of the risks such as uninformed patients and healthcare workers(doctor/nurse), as well as maintenance of incorrect beliefs regarding maternal and neonatal vaccination; lack of active promotion of the vaccination policy by health authorities; and Insufficient availability of some vaccines to cover all pregnant women on time.

Due to the issues presented above, and with the need to facilitate the people's tracking system as important to ensure they are well-being, and security of pregnant mother and children under five years; it is important to develop an application refers to Vaccination Tracking Information System for pregnant mothers and children under five years in Rwanda where after performing a basic analysis of the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department; the system is designed to use it registering and tracking individual vaccination status, and generate more accurate population estimates and vaccination targets in vaccination department; it will help RBC Rwanda to identify and reminded families when vaccinations were due or missed; the doctors (Nurses)monitor vaccination coverage and vaccinator performance in easy way; and the designed system is also configured to send out reminders to parents about upcoming appointments(notifying the patient about the appointment). This covered the gap left by previous IT engineers who did not address the existing issues to support vaccination department to tracking vaccinated pregnant mothers and children.

1.3 Research Objectives

This study was divided into two categories: general and specific objectives

1.3.1 General Objective

The main objective of this research project was to design and develop a proper vaccination system to replace existing manual procedure that can help vaccination department to get every vaccine to schedule on a date for pregnant mother and child in Rwanda using Vaccination Tracking Information System.

1.3.2 Specific Objectives

The specific objectives were fulfilled in this study:

i. To register and track individual immunization status and generate more accurate population estimates and vaccination targets in vaccination department.
ii. To present an overview of a digital vaccination system and gives patient an appointment with the automated notification for next vaccines.
iii. The system will help RBC Rwanda, the doctors (nurses) will monitor vaccination coverage and vaccinator performance in easy way.
iv. To perform a basic analysis of the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department.
v. To monitor vaccination activity of their children or pregnant mother in easy way.

1.4 Research Questions

The study answered the following questions:

i. Is the system used to register and track individual immunization status, and generate more accurate population estimates and vaccination targets in vaccination department?
ii. Is the system be also configured to send out reminders to parents about upcoming appointments?
iii. Does the system help RBC Rwanda especially for Doctor and Nurses to monitor vaccination coverage and vaccinator performance in easy way?
iv. How is the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department?
v. How the Parents can easily monitor vaccination activity of their children or pregnant mother?

1.5 Scope of the Study

This study will be limited in time scope, methodological scope, content scope and geographical scope;

1.5.1 Content scope

This project is to be carried out at Vaccination department in RBC Rwanda, which is responsible for Tracking vaccination records about pregnant mothers and children under five years through health centers where those both categories of patients can access the service. Owing to the limitation of time and resources, the researcher has devoted all her research effort to develop a web-based system to track vaccination records for pregnant mothers and child under five years. Basically, it identifies the depth of the study and the parameters within the study/project will be operating.

1.5.2 Geographical scope

In terms of space, the research doesn't focus on all IT projects alignment operating in Rwanda; it focuses only to information system for vaccinations monitoring in expectant pregnant mothers and children under five years in RBC-Rwanda because of short time the researcher has during this study. Geographic scope is the area covered by a model or analysis used to calculate physical changes resulting from a proposed project.

1.5.3 Time scope

Regarding time, it has been taken one year, from October 2022 to October 2023 to be completed. This period is not chosen haphazardly; because the study will evaluate the progress of the RBC-Rwanda in Information System for vaccination monitoring in expectant pregnant mother and child in Rwanda. Time scope is such portion of time reasonably required in order to mention or state categorically the time periods the study will cover.

1.6 Significance of the Study

After observing the service relating vaccination records for children under five years and pregnant women going to different health centers in wide country which is manually done and cause time and money wasting, researcher has found that her project is one-way handling the mentioned problem.

1.6.1. Personal Interest

- To the researcher, myself as other scholars, the current study will enable me in academic to satisfy the requirement of ULK for an award of master's degree.
- To improve my knowledge in the field of software development.

1.6.2. University Interest

- The findings may also be useful to future researchers as it will become a reference document.
- To the scientific and academic, this study will be the source of information about ICT project especially vaccination tracking information system because the current study will add a value knowledge to already existed literatures.

1.6.3. Public Interest

The study has great significant to the community and the civil society through designing the vaccination tracking information system for pregnant mother and child in Rwanda.

- To help RBC Rwanda vaccination department to achieve the goal of making the use of Information and communication Technology as a key tool.
- To help nurses and doctors by minimizing the time of searching such information relating to pregnant mother or child.
- It will be useful to development actors in Government, community, funding agencies in the vaccination tracking information system especially those who are in charge to track information for vaccination of pregnant mother and child in Rwanda.

1.7. Project Methodology

This section presents the methodology employed for data collection and the software development process model used in this research study. The objective was to gather comprehensive and relevant information related to the subject under study, utilizing appropriate
techniques and tools.

- **Design the System Architecture** that I have Created a data flow diagram of system architecture that outlines the flow of data and interactions between components Include a database, and a user interface using WonderShare EdrawMax software,

- MySQL used to create the database and PHP for application, this software is development in HTML and CSS to design a user interface for administrator and Nurses.
- **Validation and Verification**: The software development process model should emphasize thorough validation and verification techniques. Rigorous testing, including unit testing, integration testing, and user acceptance testing, is essential to ensure the accuracy and reliability**.**
- For **Security Measures,** i have implemented the security features to protect the system and user data validation. This includes encryption, access controls, and secure data transmission.

1.8 Limitation of the Project

During this research i have faced some obstacles and limitations where by the documentation relating to Vaccinations of Children under five years and pregnant mothers was not easy to find all processes that have done for a child or pregnant mother in order to receive the vaccine. The current database does not include records of vaccinations administered in past to be used in different services of vaccinations therefore, it will be necessary for database to include records of immunizations given prior to the development of this system.

1.9 Structure of the Project

The work was divided into five chapters. The first chapter is related to the general introduction of this project. It contains the statement of the problem, research objectives, questions, hypothesis, the scope of the project, significance of the study, methodology, definitions of key concepts, structure of the thesis, and Duration of the project. The second chapter is Literature review, it deals with the conceptual review, the theoretical concepts, review of related literature and review of related literature. The third chapter deals with system analysis and design. The fourth chapter provides the analysis, development, and implementation of the system. The fifth chapter includes the conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter contains introduction, conceptual review explains in details the key concepts related to the topic understudy by making a reference to definitions of previous authors, theoretical review based on theories that helpful the define the current study, review of related literature is called also empirical studies that show different articles, thesis and dissertations which help to know how they have resolved their problems related to the software, and conceptual framework describes the variables include the study topic.

2.2 Conceptual Review

2.2.1 Definitions of Key Concepts

- **Vaccination Tracking Information System**

Vaccination, also known as immunization, is a medical procedure that involves the administration of a vaccine to an individual with the purpose of stimulating their immune system to develop immunity against a specific infectious disease. Vaccines typically contain weakened or inactivated forms of the disease-causing microorganism (such as a virus or bacteria), parts of the microorganism, or synthetic substances that mimic the microorganism (World Health Organization , 2020).

- **Tracking Information System (TIS)**

It is a software-based solution or a combination of hardware and software used to monitor and track various types of assets, objects, or information in real-time or over a specified period (Smith, J., 2021).

- **Information System for vaccination Monitoring (ISVM)**

It is a digital or computerized system designed to record, manage, and monitor information related to vaccinations within a specific population or healthcare system. This system is typically used by public health authorities, healthcare providers, and relevant government agencies to collect, store, and analyze data regarding vaccination efforts. These systems are critical for public health efforts, especially during vaccination campaigns, routine

immunization programs, and in response to outbreaks or pandemics. Here is an overview of a typical Vaccination Tracking Information System:

- **User Management:**

ISVM typically includes role-based access control, allowing different users to access and input data based on their roles. Users may include healthcare workers, administrators, data entry personnel, and public health officials.

- **Patient Registration:**

The system allows for the registration of individuals who need to be vaccinated. This may involve capturing demographic information, contact details, and relevant medical history.

- **Appointment Scheduling:**

Information System for Vaccination monitoring in expectant pregnant mothers and Chlidren under five years allow to reminder the parents about upcoming appointment with the automated notification system.

- **Vaccination Record Keeping:**

The system records the type of vaccine administered to the patient, date and time of administration, and the healthcare staff(nurse) who administered it. This data is crucial for tracking individual vaccination histories.

- **Dose Tracking:**

Many vaccines require multiple doses, and the VTIS can help in scheduling and tracking follow-up doses to ensure individuals receive the complete vaccination series.

- **Reporting and Analytics:**

Public health officials can generate reports and analyze data to assess the progress of vaccination campaigns, identify coverage gaps, and make informed decisions regarding resource allocation.

1.8.2 Pregnant Mother and Child Vaccination

Pregnancy is a unique and transformative experience in a woman's life as she prepares to bring a child into the world. It involves a series of physiological, emotional, and psychological changes for both the pregnant mother and the developing child (American College of Obstetricians and Gynecologists, 2021).

Being a **pregnant mother** is a unique and transformative experience in a woman's life. Pregnancy typically lasts around nine months.

A child is typically defined as a human being who is in the early stages of development between infancy and adolescence. While the exact age range considered to be childhood may vary from one culture or jurisdiction to another, it generally encompasses the period from birth to the onset of puberty. Childhood is characterized by physical, cognitive, emotional, and social growth and maturation (March of Dimes, 2020).

- **Data Security:**

Given the sensitivity of health data, VTIS must have robust security measures in place to protect patient information and ensure data privacy. This may include encryption, authentication, and access controls.

- **Child Vaccination:**

is a medical practice that involves administering vaccines to children to protect them from various diseases. Child vaccination is an essential component of public health programs worldwide because it can Prevent Disease like measles, mumps, rubella, polio, hepatitis B, and many others.

Herd Immunity means that When a significant portion of a population is vaccinated against a disease, it can create herd immunity., Reduce Disease Spread means that Vaccination reduces the transmission of diseases, leading to fewer outbreaks and a lower overall disease burden in communities, Prevent Complications means that Vaccination not only prevents the disease but can also reduce the severity of illness if a vaccinated person does get infected. Parents and caregivers are usually provided with vaccination records to keep track of their child's immunizations. Regular check-ups with healthcare providers help ensure that children receive the recommended vaccines on time.

- **Pregnant mother Vaccination**

Vaccination during pregnancy is an important aspect of prenatal care and maternal health. It can help protect both the pregnant mother and her developing fetus from certain infectious diseases. The vaccines recommended during pregnancy are Influenza (Flu) Vaccine, Tdap Vaccine and COVID-19 Vaccine if not taken. Pregnant mother vaccination is very important in protecting both the mother and the baby from potentially severe infections outweigh any potential risks.

- **Manuel System**

It refers to a system or process that is operated and managed by human effort without the use of automated tools, computers, or electronic systems. Instead, tasks and operations are performed manually, often using paper-based records or traditional methods.

2.1.2 Information System for Monitoring Vaccinations

According to (Capobianco E. & Naidu V., 2018), Vaccination is the act of introducing a vaccine into the body to produce protection from a specific disease. Subunit, recombinant, polysaccharide, and conjugate vaccines use specific pieces of the germ like its protein, sugar, or capsid (a casing around the germ). Because these vaccines use only specific pieces of the germ, they give a very strong immune response that's targeted to key parts of the germ.
Immunization is a process by which a person becomes protected against a disease through vaccination. This term is often used interchangeably with vaccination or inoculation. Vaccine Information Statements (VISs) are information sheets produced by the CDC that explain both the benefits and risks of a vaccine to vaccine recipients. Federal law requires that healthcare staff provide a VIS to a patient, parent, or legal representative before each dose of certain vaccines (Sabin , 2017).

2.1.3 Pregnant Mother and Child Mortality

Global progress in reducing deaths of pregnant women, mothers and babies has flatlined for eight years due to decreasing investments in maternal and newborn health, according to a new report from the United Nations (UN). The report shows that over 4.5 million women and babies die every year during pregnancy, childbirth or the first weeks after birth - equivalent to 1 death happening every 7 seconds mostly from preventable or treatable causes if proper care was available. Pregnant women and newborns continue to die at unacceptably high rates worldwide,

and the COVID-19 pandemic has created further setbacks to providing them with the healthcare they need. Maternal, Newborn, Child and Adolescent Health and Ageing at the World Health Organization (WHO). (Elsevier; 8th edition, April 18, 2023)

More and smarter investments in primary healthcare are needed now so that every woman and baby no matter where they live has the best chance of health and survival. To increase survival rates, women and babies must have quality, affordable healthcare before, during and after childbirth, the agencies say, as well as access to family planning services. More skilled and motivated health workers, especially midwives, are needed, alongside essential medicines and supplies, safe water, and reliable electricity. The report stresses that interventions should especially target the poorest women and those in vulnerable situations who are most likely to miss out on lifesaving care including through critical subnational planning and investments. (Buttram , 2021)

Child mortality refers to the death of children under the age of five. It is a crucial indicator of a population's overall health and well-being, as well as the quality of healthcare and living conditions in a particular region or country. High child mortality rates are typically associated with factors such as poor nutrition, inadequate access to healthcare, lack of clean water and sanitation, infectious diseases, and socio-economic disparities.

Pregnant mother and child mortality are critical public health indicators that reflect the overall health and healthcare infrastructure of a region. Maternal mortality refers to the death of a woman during pregnancy, childbirth, or in the postpartum period, due to causes related to pregnancy or its management. Child mortality, often referred to as under-five mortality, measures the number of deaths of children under the age of five per 1,000 live births. Child mortality is a key indicator of a nation's healthcare system and overall development. Efforts to reduce maternal and child mortality often focus on improving healthcare infrastructure, increasing access to prenatal and postnatal care, promoting maternal and child nutrition, ensuring safe and clean birthing practices, and educating communities about the importance of family planning and proper maternal and child healthcare (Alkema, et al., 2018)

2.3 Theoretical Review

2.3.1 Systems Thinking theory

Systems thinking originated in 1956 when Professor Jay Forrester founded the Systems Dynamic Group at MIT's Sloan School of Management. Systems theory aids in understanding and recognition that the project is a system embedded in the larger system of the organization (Kapsali, 2018). Systems thinking is a holistic approach to analysis that focuses on the way that a system's constituent parts interrelate and how systems work over time and within the context of larger systems. The systems thinking approach contrasts with traditional analysis, which studies systems by breaking them down into their separate elements. Systems thinking can be used in any area of research and has been applied to the study of medical, environmental, political, economic, human resources, and educational systems, among many others.

Systems thinking is an interdisciplinary approach to understanding and solving complex problems. It views systems as interconnected and interdependent, emphasizing the relationships and interactions between various components rather than focusing solely on individual elements. Systems thinking theory has been applied in various fields, including management, engineering, environmental science, and social sciences.

Here are some key concepts and principles of systems thinking included holistic perspective; feedback loops; systems archetypes; boundaries; emergence; mental models; systems Dynamics; Causal Loop Diagrams (CLDs); leverage points; interconnectedness and interdependence; time delays. overall, systems thinking provides a powerful framework for tackling complex and systemic issues by considering the broader context, relationships, and dynamics that influence them. It promotes a more holistic and long-term approach to problem-solving and decision-making.

The characteristics of systems thinking; according to systems thinking, system behavior results from the effects of reinforcing and balancing processes. A reinforcing process leads to the increase of some system component. If reinforcement is unchecked by a balancing process, it eventually leads to collapse. A balancing process is one that tends to maintain equilibrium in a particular system. Attention to feedback is an essential component of system thinking. For example, in project management, prevailing wisdom may prescribe the addition of workers to a project that is lagging. However, in practice, that tactic might have actually slowed development in the past. Attention to that relevant feedback can allow management to look for

other solutions rather than wasting resources on an approach that has been demonstrated to be counterproductive.

Methodologies of systems thinking; systems thinking uses computer simulation and a variety of diagrams and graphs to model, illustrate, and predict system behavior. Among the systems thinking tools include the behavior over time (BOT) graph, which indicates the actions of one or more variables over a period of time; the causal loop diagram (CLD), which illustrates the relationships between system elements; the management flight simulator, which uses an interactive program to simulate the effects of management decisions; and the simulation model, which simulates the interaction of system elements over time. Critical on systems thinking based on how the systems approach designed to aid decision-makers, and other stakeholders, improve complex problem situations that cross departmental and, often, organizational boundaries.

During this study, the vaccination tracking information system plays important role to advanced health technology. The vaccines can prevent people from infectious disease. Vaccination is an effective method for developing the individual`s immune system and protect people from a pathogen. The current existing manual system has a lot of problems, so it does not provide a better result for the people of Rwanda in vaccination department.

The main problem is improper health centers management in vaccination services, most parents when they lost their children vaccination schedule cards which is very important to provide the information to their children nurses cannot find the information related to those patients who come to the health center; therefore, there is a delay for service, and this process of vaccination is paper based which is not secure. The motivate of this project is a web-based system which can be used by admin and nurses in vaccination tracking information system whereby the admin can manage the process of the system and nurses manage the information of patients (children under five years and pregnant mothers).

2.4 Review of Related Literature

2.4.1 Rapid SMS System in Rwanda

According to (Musabyimana et al., 2018), Rapid SMS system in Rwanda is an innovative mobile technology tool that saves lives by tracking pregnant women, newborns and children under two years of age at community and health facilities that receives reports on key MNCH indicators from over 45,000 community Health Workers (CHWs) in 15,000 villages across

Rwanda. The Rapid SMS-MCH system was designed to provide an SMS-based platform, enabling effective and real-time two-way communication for action, between CHWs at community level, and the rest of the health system through mobile phones.

Rapid SMS provides a database for keeping clinical records of maternal, Newborn and Child care delivery. Rapid SMS technology receives short messages (sms) from CHWs and sends a short feedback message to a centralized computer which is able monitor incoming information about emergencies (red alerts) and high-risk cases in real time, and provides a reminder when follow up care is required. Rapid SMS was customized for application to track key maternal, newborn and child health indicators across all villages in Rwanda. Mobile Health (mHealth) programs have increasingly been used to tackle maternal and child health problems in low- and middle-income countries.

However, few studies have evaluated how these programs have been perceived by intended users and beneficiaries. Therefore, we explored perceptions of healthcare officials and beneficiaries regarding Rapid SMS Rwanda, an mHealth system used by Community Health Workers (CHWs) that was scaled up nationwide in 2013. They conducted key informant interviews and focus group discussions with key stakeholders, providers, and beneficiaries of maternal and child health services at both the national and community levels.

Semi-structured interviews were used to assess perceptions about the impact of and challenges facing the Rapid SMS system. Interviews and focus group discussions were recorded (with the exception of one), transcribed verbatim, and analyzed. The results show that the they conducted a total of 28 in-depth interviews and 10 focus group discussions (93 total participants). A majority of respondents believed that Rapid SMS contributed to reducing maternal and child mortality rates. Rapid SMS was generally accepted by both CHWs and parents. Participants identified insufficient training, a lack of equipment, and low CHW motivation as the main challenges facing Rapid SMS.

The findings suggest that a Health program can be well accepted by both policymakers, health providers, and the community. We also found significant technical challenges that have likely reduced its impact. Addressing these challenges will serve to strengthen future mHealth programs (Musabyimana et al., 2018).

2.4.2 Electronic Immunization Information Systems in Pakistan

According to (Erin Sullivan et al., 2020); the immunization information system comprised of a web portal and integrated mobile messaging platform. The web portal allowed users to store data on individual children and pregnant women; manage, search, and filter client records; and monitor vaccination coverage and vaccinator performance. The portal had a universal login and a set of dashboards to track due doses of vaccines that helped to identify and guide follow-up with defaulters. An integrated mobile messaging platform with web and API access sent short message service (SMS) vaccination reminders and five different awareness messages to caregivers; one reminder for vaccinators to visit specific villages based on their micro plans; and one notification to community focal persons informing them that vaccinators would be visiting their villages on certain dates. Pakistan ranks third globally in the number of unvaccinated and under-vaccinated children, and Sindh province has one of the lowest vaccination rates in the country.

Electronic census-based immunization information systems have the potential to bolster traditional immunization service delivery mechanisms, but literature has largely not focused on implementation at scale in Pakistan. This is a case report of technical support provided to the Sindh Department of Health/Expanded Program on Immunization (DOH/EPI) from 2015 to 2017 to strengthen routine immunization (RI). The program developed an immunization information system used by district health officers to register and track individual immunization status, improve vaccine logistics, and generate more accurate population estimates and vaccination targets. District immunization officers (DIOs) assisted their district health management teams and supervisors to use registration and service data stored in the immunization information system database to prepare micro plans, monitor catchment area performance, and solve problems. Civil society partners registered 830,610 children (aged 0 to 23 months) and 348,315 pregnant women in 28,565 villages over an 18-month intensive intervention period.

By the end of this period, 65% of all registered women had been vaccinated with two or more doses of the tetanus toxoid vaccine (compared to 26% at baseline); Penta 3 vaccination coverage had increased from 27% to 64%; and 52% of the registered children (aged 0 to 23 months) were fully immunized (compared to 18% at baseline). The immunization information system helped district managers identify and focus limited resources on high-risk populations; reminded families and health providers when vaccinations were due or missed; assisted

managers in monitoring vaccination coverage, vaccinator performance, and vaccine stocks; and encouraged local problem solving to improve RI performance. The Government of Sindh demonstrated a commitment to RI based on the program's results, which bode well to future enhancements and scale up.

2.5 Conceptual Framework

In order to solve the problem of the study, the researcher establishes the relationship between independent variable in terms of Vaccination tracking information system while dependent variable represented by Pregnant Mother and Child. The conceptual framework is shown in the figure 1 as follows:

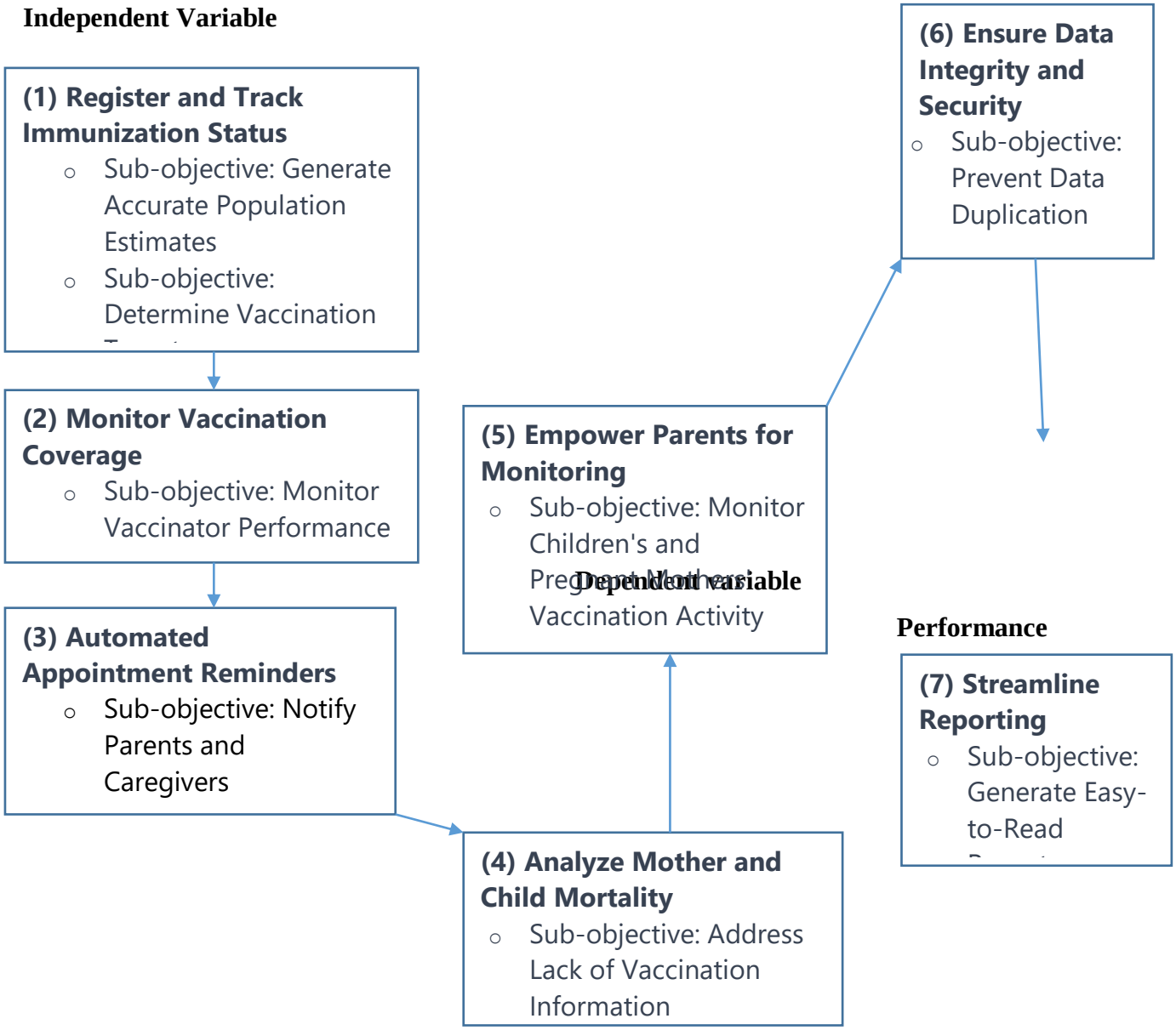


Figure 1: ***Conceptual Framework***

CHAPTER 3: SYSTEM ANALYSIS AND DESIGN

3.1 Introduction to the Study

This chapter goes over the specifics of the software engineering methodology that was used. It makes an attempt to identify the source of data as well as the methods and techniques used to collect data that were analyzed and interpreted in order to develop such an application. It also includes an examination of the current information system, particularly the Vaccination tracking information System for pregnant Mother and Child.

3.2 System Analysis

Systems analysis is a process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. System analysis is conducted for the purpose of studying a system or its parts in order to identify its objectives. The problems, and recommends feasible suggestions for improving the system functioning.

This involves studying the business processes, gathering operational data, understand the information flow, finding out bottlenecks, and evolving solutions for overcoming the weaknesses of the system so as to achieve the organizational goals. System Analysis also includes subdividing a complex process involving the entire system, identification of data store, and manual processes.

3.3 Analysis of the New System

3.3.1 Introduction

A developed web application system and mobile application for Vaccination Information System in the view of solving problems that arise when using the current manual system. In Vaccination Tracking Information System project helps to solve the problem of tracking the vaccination records for individual pregnant mother and child and also the project helps the vaccination department to referral and retrieval of information on vaccination history of previous treatment administrated to those children and pregnant mother.

This is easy way to check and find if the nurse is the one who previous treated the child or pregnant mother. This project solves the issue whereby it should allow vaccinators and the nurse to register and track the vaccination status of individual women and children and monitor vaccine usage. Expectations are that it also auto-generated and send reminder messages to families when come for next vaccine doses are due or a vaccination is missed.

3.3.2 Weakness Observed in the Current System

A problem usually arises when a guardian (parents) for a child or pregnant mother forget or lost their child vaccines schedule cards at home as she/he may be required to return home to pick it or it was completely lost, which is very important thing in vaccination process thus, it is a time-consuming process and sometimes may lead to absconding because the current system which is fully manual.

3.4 Research Methodology

3.4.1 Introduction

Methodology is the specific set of methods, procedures, and techniques used in conducting research, means that principles or rules from which specific methods or procedures may be derived to interpret or solve different problems within the scope of a particular discipline. Unlike an algorithm, a methodology is not a formula but a set of practices. These methods are chosen based on the nature of the research, the type of data required, and the research objectives. Research methods provide a practical way to implement the broader research methodology. Different approaches are used in the software development process, such as waterfall, prototyping, spiral, etc. The methodology for the software development process model that were used in this project is the waterfall model.

3.4.2 Research Design

System design is the first phase of the system development life cycle in which you and the user develop a concrete understanding of how the system operated and it refers to the process of defining and detailing the architecture, components, modules, interfaces, and functionalities of a complex system. It involves translating the requirements and specifications of a system into a well-structured and organized plan that serves as a blueprint for development, implementation, and maintenance.

3.4.3 Population and Sample Size

A population is the entire group that you want to draw conclusions about. A sample is the specific group that collected data from. The size of the sample is always less than the total size of the population. In this study, the target population was 41 people from RBC in charge of vaccination distribution and tracking. The sample size of the study was all these 41 people taken as whole using census survey for gathering necessary information about vaccination tracking information.

3.4.4 Data Collection Instruments

Data collection is the process of gathering relevant information or data from various sources to support research, analysis, decision-making, or other objectives. The goal for all data collection is to capture quality evidence that translates to rich data analysis and allows the building of a convincing and credible answer to questions posed. For the project, I used it to collect data to achieve the objective.

3.4.4.1. Documentation Study Technique

This kind of technique allows the researcher to consult different documents like Books in the Library and the notes of class, and other documents related to this Project. Concerning this technique, it was very difficult to get the hard copy to talk about the vaccination Tracking system at ULK library but we consulted some online books and documents.

3.4.4.1.2. Interviews Techniques

I have used Interviews technique that involved one-on-one with participants to elicit facts or statements from the interviewee and gather in-depth information and insights and it was structured (means that following a predefined set of questions), and Interviews technique is a standard part of qualitative research. In this research, the interview is addressed to the patients or beneficiaries (pregnant mother) of vaccines.

3.4.4.1.3. Questionnaires technique

I have structured sets of questions that participants fill out and those questions are based on the information that I need and it was administered in person, via mail. The questionnaire constituted by closed end questions addressed to respondents from RBC.

3.5 Data Processing and Analysis

Data processing refers to the series of actions taken to organize, clean, transform, analyze, and interpret raw data into meaningful information. The goal of data processing is to extract valuable insights, trends, patterns, and conclusions from the collected data. It should also see the programming tools and languages used to process data in the coding process. There are many development life cycle models that have been developed in order to achieve different required objectives. The models specify the various stages of the process and the order in which they are carried out, therefore in this project I have used waterfall, because it is very simple to understand and use.

3.5.1 Profile of Respondents

This sub-section presents the findings from perception of respondents on gender, age, and describe whether respondent is parent or caregiver of a child under the age of five. Findings in table 3.2 presents socio-demographic characteristics of respondents.

Table 1*:Profile of Respondents*

	Data	Frequencies	Percentages
Gender	Females	28	68.3
	Males	13	31.7
	Total	**41**	**100.0**
Age	18-24 years	10	24.4
	25-34 years	20	48.8
	35-44 years	8	19.5
	45-54 years	3	7.3
	Total	**41**	**100.0**
Whether you are Nurse or doctor of a child under the age of five	Yes	35	85.4
	No	6	14.6
	Total	**41**	**100.0**

Source: *Primary data (2023).*

The findings indicated in table 3.2 show socio-demographic characteristics of respondents which confirmed that 28 or 68.3% respondents in this study were females while 13 or 31.7% were males. Concerning to age of respondents; the study findings show that 10 or 24.4% respondents have age ranging between 18-24 years; majority of 20 or 48.8% have age between 25-34 years; 8 or 19.5% respondents have age between 35-44 years and 3 or 7.3% have age range from 45-54 years.

3.5.2 ISMV for Pregnant Mothers and Children Under Five Years in Rwanda.

Findings in this section show perceptions of respondents on the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department; the system is used to register and track individual immunization status, improve vaccine logistics, and generate more accurate population estimates and vaccination targets in vaccination department; whether the system helps RBC Rwanda to identify and focus limited resources on high-risk populations; reminded families and health providers when vaccinations were due or

missed; the doctors (nurses) monitor vaccination coverage, vaccinator performance and vaccine stocks in easy way; and the system is also configured to send out reminders to parents about upcoming appointments.

Table 2*:Opinions on pregnant mother and child mortality cases due to lack of vaccination information.*

Statements	**SA**		**A**		**N**		**D**		**SA**	
	fi	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**
Pregnant women and children miss out on essential vaccinations due to a lack of information or access to vaccination services;	15	36.6	8	19.5	1	2.4	9	22.0	8	19.5
Pregnant women do not receive proper prenatal care, including information about vaccinations leads to complications during pregnancy or childbirth;	13	31.7	5	12.2	2	4.9	8	19.5	13	31.7
Lack of awareness about vaccination schedules and timely vaccinations result in missed opportunities;	13	31.7	16	39.0	2	4.9	4	9.8	6	14.6
Some of the children under five still do not receive vaccinations which lead to risk of severe illnesses, hospitalizations, or even death;	14	34.1	10	24.4	1	2.4	1	2.4	15	36.6
Low vaccination rates within a community lead to reduced herd immunity, making it easier for infectious diseases to spread;	15	36.6	17	41.5	2	4.9	0	0.0	7	17.1

Source: *Primary Data, Field results (2023)*

Findings in table 3.3 indicated the perception of respondent on how is the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department. The results revealed that pregnant women and children miss out on essential vaccinations due to a lack of information or access to vaccination services as confirmed by 36.6% strongly agreed and 19.5% agreed about the statement.

Pregnant women do not receive proper prenatal care, including information about vaccinations leads to complications during pregnancy or childbirth as confirmed by 31.7% strongly agreed and 12.2% agreed. Lack of awareness about vaccination schedules and timely vaccinations result in missed opportunities confirmed by 31.7% strongly agreed and 39.0% agreed.
Some of the children under five still do not receive vaccinations which lead to risk of severe illnesses as stated by 34.1% strongly agreed and 24.4% agreed. Low vaccination rates within a community lead to reduced herd immunity, making it easier for infectious diseases to spread as strongly agreed by 36.6% and 41.5 % agreed. Some general insights into how a lack of vaccination can potentially impact pregnant women and children through Increased Risk of Vaccine-Preventable Diseases where when individuals, including pregnant women and children, do not receive recommended vaccinations, they are at a higher risk of contracting vaccine-preventable diseases such as measles, mumps, rubella, polio, and others. These diseases can lead to severe complications and mortality, particularly in vulnerable populations. Complications during Pregnancy where Pregnant women who are not vaccinated against diseases like influenza and tetanus may be more susceptible to infections, which can lead to complications during pregnancy, including premature birth and maternal mortality. Transmission to Infants where Newborns and infants are particularly vulnerable to infections, as their immune systems are not fully developed.

If a pregnant woman contracts a vaccine-preventable disease, she can potentially transmit it to her child, putting the child's health at risk. Healthcare System Strain where a high prevalence of vaccine-preventable diseases can strain healthcare systems, making it more challenging to provide adequate care to pregnant women and children, especially in resource-limited settings.

Table 3*:Designed system can identify high-risk populations; reminded families and health providers when vaccinations were due or missed;*

Statements	**SA**		**A**		**N**		**D**		**SA**	
	fi	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**	**fi**	**%**
The designed system effectively can help RBC Rwanda to identify high-risk populations/pregnant mother and children under five years missed vaccines;	11	26.8	14	34.1	11	26.8	3	7.3	2	4.9
The system consistently can remind families and health providers when	9	22.0	14	34.1	8	19.5	7	17.1	3	7.3

vaccinations are due or have been missed;										
The system can facilitate doctors and nurses in monitoring vaccination coverage in an easy and efficient manner;	13	31.7	12	29.3	9	22.0	6	14.6	1	2.4
The system can allow for easy monitoring of vaccinator performance in delivering vaccines;	19	46.3	12	29.3	4	9.8	2	4.9	4	9.8
The system can help in maintaining adequate vaccine stocks, ensuring a steady supply for immunization programs;	17	41.5	12	29.3	8	19.5	3	7.3	1	2.4

Source: *Primary Data, Field results (2023)*

Findings in Table 3.4 indicated the perceptions of respondents on whether system can help RBC Rwanda to identify and focus limited resources on high-risk populations; reminded families and health providers when vaccinations were due or missed; the doctors (nurses) monitor vaccination coverage, vaccinator performance and vaccine stocks in easy way. More than 26.8% strongly agreed and 34.1% agreed that the designed system effectively can help RBC Rwanda to identify high-risk populations/pregnant mother and children under five years missed vaccines.

More than 22.0% strongly agreed and 34.1% agreed that the system consistently can remind families and health providers when vaccinations are due or have been missed. The 31.7% strongly agreed and 29.3% agreed that the system can facilitate doctors and nurses in monitoring vaccination coverage in an easy and efficient manner. Beyond of 46.3% strongly agreed and 29.3% agreed that the system can allow for easy monitoring of vaccinator performance in delivering vaccines. More than 41.5% strongly agreed and 29.3%.

3.5.3 Waterfall Model

The Waterfall Model was first Process Model to be introduced. It is also referred to as a linear sequential life cycle model. It is very simple to understand and use. In a waterfall model, each phase must be completed fully before the next phase can begin. In this model the testing starts

only after the development is complete. In waterfall model phases do not overlap. (k. Hoory, L., & Bottorff, C, 2022)

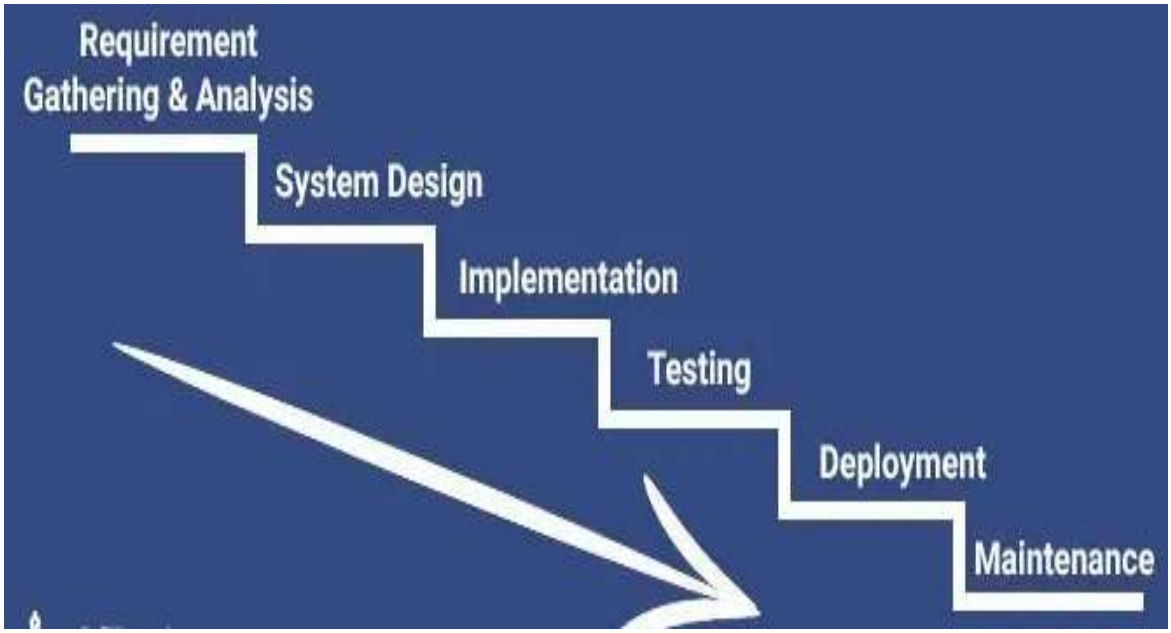


Figure 2: ***Waterfall model***

The waterfall model is a sequential software development model in which the development is seen as flowing steadily downwards (like a waterfall) through the phases of requirements analysis, design, implementation, testing (validation), integration, and maintenance. (Phil Lombardi, 2022)

3.5.4 Phases of Waterfall Model

1) Requirement gathering and analysis phase

This is the crucial phase where all possible requirements of the system to be developed are captured in this phase and documented in requirement specification document.

2) System Design phase

This phase looks at how the software will be built and how the system will operate, emphasizing hardware, software, network infrastructure, and user interface.
The requirement specifications from first phase are studied in this phase and the system design is prepared and this helps in specifying hardware and system requirement therefore helps defining the overall system architecture. Here we have two types of design to be considered:

- ✓ Logical Design: it includes the design of forms and reports, the design of the interface, and the database design.
- ✓ Physical Design: it is concerned with designing the physical database, the programs and processes and the distributed systems.

In this research, I have developed a web-based and an android application which can be used by admin or staff to monitor child vaccination system. The proposed system architecture has been designed on the basis of three-tier architecture. The Three-tier architecture consists of the presentation layer, application layer, and data storage layer. The system design describes detailed information of this proposed system.

3) Implementation and Unit Testing Phase

After receiving inputs from the system design, the system is firstly developed in small programs called" Units" which are integrated in next phase, means that real coding is commenced.
Every unit is developed and tested for its functionality which is referred to as "Unit Testing"

4) The Integration System and Testing Phase

All the units developed in implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures.

5) Deployment of the system

Once the functional and non-functional testing is done; the software product is delivered to the customer environment. or released into the market.

6) Operations and Maintenance phase

It is a never-ending phase. Once the system is running in production environment, there are some problems which come up in client environment and fix those issues, also to enhance the product some better versions are released. So, maintenance is done to deliver those changes in the customer environment.

3.5.5 Information System for Monitoring Vaccinations into a Waterfall Model:

1. Requirements Gathering and Analysis:

• Define the specific requirements for Vaccination Tracking Information System in vaccination Department at RBC

This includes understanding the needs of health centers countrywide, services required by patients, and its professionals.

• Gather detailed requirements for data sources, system algorithms, user interfaces, security, and compliance with vaccination department regulations.

2. System Design:

• Create a detailed system design based on the gathered requirements. This includes designing the architecture and design of the system.

• Define the data flow, data storage, and integration points with health center data sources, such as electronic patient records (EPRs) and vaccinations types.

• Design the user interfaces for vaccinations tracking professionals and patients.

3. Implementation

• Develop the software components of the system which including system algorithms, data processing modules, and user interfaces.

• Implement data collection, data preprocessing, and data cleaning procedures to prepare vaccination tracking data for system.

• Integrate external libraries and tools for system, data analytics, and visualization.

4. Testing:

• Conduct thorough testing of the developed software components. This includes unit testing, integration testing, and system testing.

• Verify that the system models produce accurate results and meet Vaccination tracking quality standards.

• Ensure the security of patient data and compliance with vaccination department privacy regulations.

5. Deployment:

• Deploy Vaccination Tracking Information System in a controlled environment, such as Vaccinations department or a testing environment, but for simulation demo I used On-Premise server, later alone on cloud for easy access to everyone via internet.

• Configure the system to work seamlessly with existing vaccinations department infrastructure.
• Provide training to health centers staff in vaccination department in order to become professionals and end-users on how to use the system effectively.

6. Maintenance and Support:

• Monitor the system's performance and system models in a real-world.
• Address any issues or bugs that arise during usage and provide regular updates and enhancements.
• Continuously improve the system algorithms based on feedback and changing vaccination tracking needs.

7. Evaluation and Feedback:

• Collect feedback from vaccination department professionals, patients, and other users to evaluate the system's effectiveness and usability.
• Use feedback to make improvements and enhancements to the system, including updates to system models and user interfaces.

Advantages of the Waterfall Model

- ✓ This model is simple and easy to understand and use.
- ✓ It is easy to manage due to the rigidity of the model
- ✓ Each phase has specific deliverables and a review process.
- ✓ In this model phases are processed and completed one at a time. Phases do not overlap.
- ✓ Waterfall model works well for smaller projects where requirements are very well understood.

Disadvantages of the Waterfall Model

- ✓ Once an application is in the testing stage, it is very difficult to go back and change something that was not well-thought out in the concept stage.
- ✓ No working software is produced until late during the life cycle.
- ✓ High amounts of risk and uncertainty.
- ✓ Not a good model for complex and object-oriented projects.
- ✓ Poor model for long and ongoing projects

3.6 System Architecture

The following system architecture demonstrates how admin and user (parents/patients) can log in by online or mobile phone, therefore admin can manage the process of a system. (Own design, 2023).

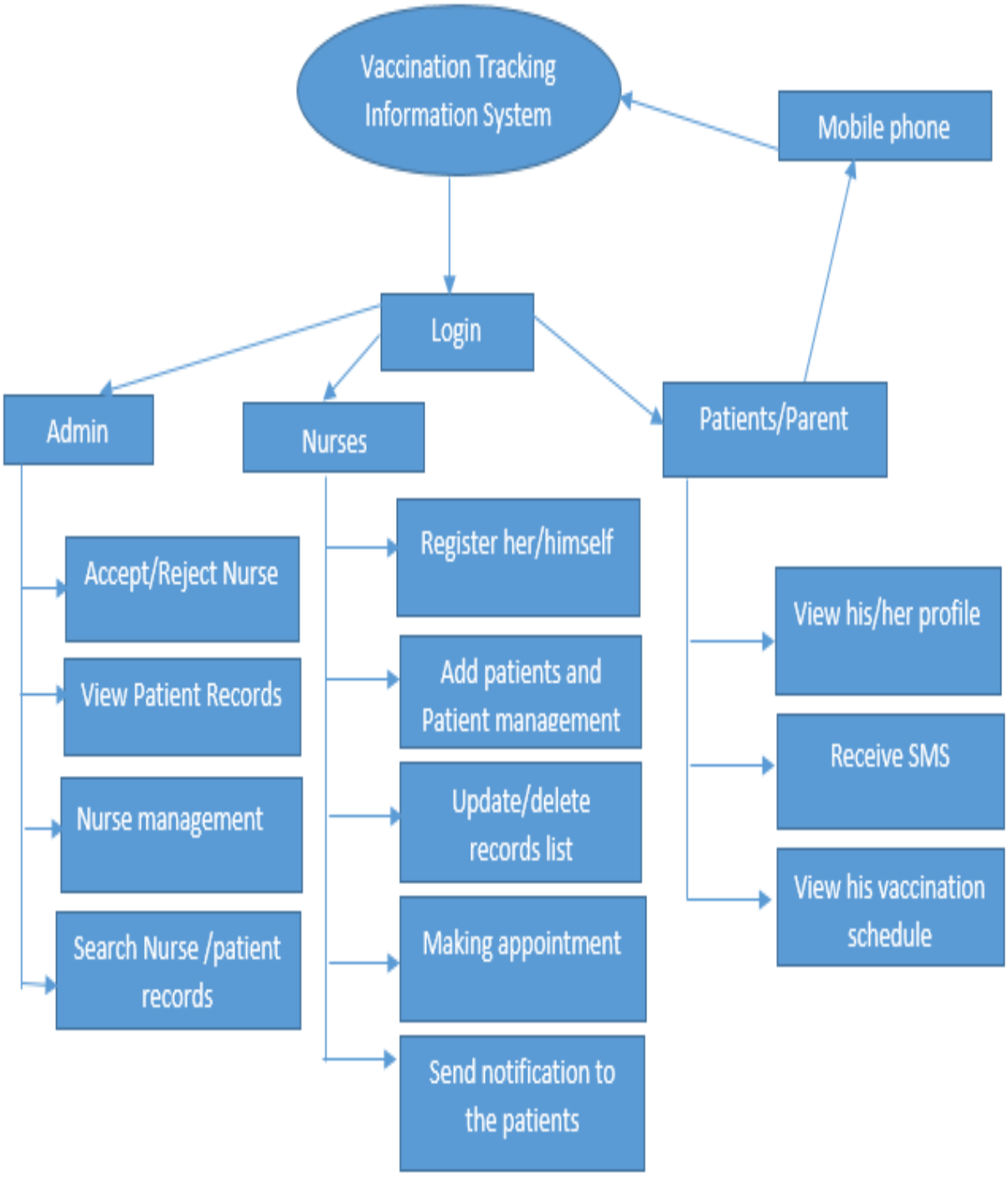


Figure 3*: Information System for Monitoring Vaccinations architecture*

3.7. Technologies Used

In this project, I have used some tools and technologies, which help me to implement the system.

3.7.1. HTML (HyperText Markup Language)

HTML, which stands for HyperText Markup Language, is the standard markup language used to create web pages and display content on the World Wide Web. It is the backbone of web development and is used to structure content and define the layout of web pages.
It is text displayed on a computer or other electronic device with references to other text that the user can immediately access, usually by a mouse click or key press. Apart from text, hypertext may contain tables, lists, forms, images, and other presentational elements. It is an easy-to-use and flexible format to share information over the Internet. Markup languages use sets of markup tags to characterize text elements within a document, which gives instructions to the web browsers on how the document should appear.
HTML was originally developed by Tim Berners-Lee in Nineteen ninety. He is also known as the father of the web. In 1996, the World Wide Web Consortium (W3C) became the authority to maintain the HTML specifications. HTML also became an international standard (ISO) in 2000. HTML5 is the latest version of HTML. HTML5 provides a faster and more robust approach to web development. (Jennifer Niederst Robbins, 2022).

3.7.1.1 Key aspects of HTML

Markup Language: HTML consists of a set of markup tags or elements that are used to define the structure and content of a web page. These tags are enclosed in angle brackets ("<" and ">").

- **Hypertext:** HTML allows the creation of hyperlinks (also known as anchor tags) that connect web pages and enable users to navigate between them by clicking on links.
- **Structured Content**: HTML provides a way to structure content using elements like headings, paragraphs, lists, tables, forms, and more. This structure helps browsers and search engines understand the content's hierarchy.
- **Text and Multimedia**: HTML supports text formatting, inline and block-level elements, and the inclusion of multimedia elements like images, audio, and video.

- **Cross-Platform Compatibility**: HTML is designed to work across different web browsers and platforms. It ensures that web content is accessible and consistent on various devices and browsers.
- **Semantic HTML**: Semantic HTML tags provide meaning and context to the content, making it more accessible to assistive technologies and improving search engine optimization (SEO).
- **HTML5**: HTML5 is the latest version of HTML and introduced many new elements and features, including audio and video support, canvas for graphics, and enhanced form elements.
- **Cascading Style Sheets (CSS):** HTML is often used in conjunction with CSS to control the presentation and styling of web pages. CSS separates the content (HTML) from its appearance.
- **JavaScript**: HTML can also be used in conjunction with JavaScript to add interactivity and dynamic behavior to web pages. JavaScript is a programming language that can manipulate HTML elements and respond to user actions.

- **Responsive Web Design**: HTML is a fundamental part of creating responsive web designs that adapt to different screen sizes and devices, providing a consistent user experience.
- **Web Standards**: HTML is developed and maintained by the World Wide Web Consortium (W3C), which sets web standards to ensure consistency and compatibility across the web.
- **Validation:** HTML documents can be validated using tools like the W3C Markup Validation Service to ensure they adhere to HTML standards and guidelines.

3.7.2. CSS (Cascading Style Sheets)

CSS, which stands for Cascading Style Sheets, is a stylesheet language used in web development to control the presentation and layout of HTML documents. CSS allows web developers and designers to define how web content should be displayed, including its appearance, positioning, colors, fonts, and more.

Key aspects of CSS:

- **Separation of Content and Presentation**: CSS separates the structure and content of a web page (defined by HTML) from its styling and layout (defined by CSS). This separation makes it easier to maintain and update websites.
- **Cascading Nature:** The term "cascading" in CSS refers to the order in which styles are applied. CSS rules can be defined in different locations, and they cascade down to affect HTML elements. The order of specificity and source determines which styles take precedence.
- **Selectors:** CSS uses selectors to target specific HTML elements to apply styles. Selectors can target elements by tag name, class, ID, attributes, and more. For example, you can use p to target all paragraphs or header to target elements with the class "header."
- **Properties and Values**: CSS properties define various aspects of an element's presentation, such as color, font-size, margin, padding, background-color, and many others. Properties are assigned values to specify how an element should be styled.
- **Box Model**: CSS uses the box model to define how elements are rendered in terms of content, padding, borders, and margins. Understanding the box model is crucial for layout design.
- Layout and **Positioning**: CSS provides tools for controlling the layout and positioning of elements on a web page. This includes properties like position, display, float, and flexbox for creating responsive and flexible layouts.

- **Responsive Design**: CSS is instrumental in creating responsive web designs that adapt to various screen sizes and devices. Media queries allow you to apply different styles based on screen characteristics.
- **Transitions and Animations**: CSS supports transitions and animations, enabling the creation of interactive and visually engaging elements on web pages.
- **Pseudo-classes and Pseudo-elements**: CSS includes pseudo-classes and pseudo-elements like: hover,:before, and :after to target elements in specific states or create additional content.
- **Vendor Prefixes**: To ensure cross-browser compatibility, developers often use vendor prefixes (e.g., -webkit-, -moz-, -ms-) for certain CSS properties to account for browser-specific implementations.

- **Preprocessors:** CSS preprocessors like SASS and LESS extend CSS with features like variables, functions, and nested rules to simplify and enhance the authoring of CSS.
- **Frameworks and Libraries**: Many CSS frameworks (e.g., Bootstrap, Foundation) and libraries (e.g., FontAwesome) provide pre-designed styles and components for faster web development.

3.7.3. JavaScript

JavaScript is a versatile and widely-used programming language primarily used for web development, but it has expanded its presence to various other application domains

Key aspects of JavaScript:

- **Client-Side Scripting**: JavaScript is primarily executed on the client-side, meaning it runs in a user's web browser. It's used to add interactivity and dynamic behavior to websites, allowing for real-time updates and user engagement without requiring constant server requests.
- **Object-Oriented Language**: JavaScript is an object-oriented language, which means it uses objects and their methods and properties to model data and behavior. This object-oriented nature makes it flexible and powerful.
- **Web Development**: JavaScript is a core technology for web development and is commonly used alongside HTML and CSS to create responsive and interactive web applications, ranging from simple scripts to complex single-page applications (SPAs).
- **ECMAScript:** JavaScript is based on the ECMAScript specification, which defines the language's core features and syntax. Modern JavaScript versions (ES6 and beyond) introduce new language features, making it more powerful and expressive.
- **Libraries and Frameworks**: There are numerous JavaScript libraries and frameworks available, such as jQuery, React, Angular, and Vue.js, which simplify and accelerate web development tasks, including DOM manipulation, state management, and component-based UI development.
- **Server-Side Development**: Node.js, a JavaScript runtime, allows developers to run JavaScript on the server-side, enabling the creation of server-side applications, APIs, and real-time web applications.
- **Cross-Browser Compatibility**: JavaScript is designed to work across different web browsers, and developers often use libraries like Babel and tools like Webpack to

ensure compatibility and transpire modern JavaScript code to older versions when needed.

- **Asynchronous Programming**: JavaScript is well-suited for handling asynchronous tasks, such as fetching data from servers, making it ideal for developing responsive and efficient web applications.
- **Event-Driven Programming**: JavaScript is event-driven, meaning it responds to events like user interactions (clicks, keypresses), timers, and server responses. Event handling is a fundamental part of JavaScript development.
- **Modern Features:** ES6 (ECMAScript 2015) introduced significant enhancements, including arrow functions, template literals, classes, and modules. Subsequent ECMAScript versions have continued to add new features and improvements.
- **Data Manipulation**: JavaScript provides powerful tools for working with data, including arrays, objects, and built-in methods for sorting, filtering, and transforming data.
- **Security Considerations**: Developers must be aware of security best practices, such as avoiding cross-site scripting (XSS) and protecting sensitive information, to ensure that JavaScript-powered applications are secure.

3.7.4. MySQL

MySQL is an open-source relational database management system (RDBMS) that is widely used for managing and storing structured data. It is one of the most popular database systems in the world and is known for its reliability, scalability, and performance.

Some key aspects of MySQL:

- **Relational Database Management System (RDBMS)**: MySQL follows the principles of the relational database model. It organizes data into tables with rows and columns, allowing for efficient data storage and retrieval.

- **Open Source**: MySQL is open-source software, which means it is freely available for use, modification, and distribution. It is maintained and developed by the MySQL community and Oracle Corporation.
- **Cross-Platform:** MySQL is compatible with various operating systems, including Linux, Windows, macOS, and more. This cross-platform compatibility makes it versatile for different server environments.

- **SQL Support**: MySQL uses Structured Query Language (SQL) as its query language. It supports standard SQL as well as some extensions and optimizations specific to MySQL.
- **Scalability**: MySQL can handle both small-scale and large-scale databases. It supports replication and clustering for high availability and scalability.
- **Performance**: MySQL is known for its speed and performance, making it suitable for high-demand web applications and data-driven websites.
- **Data Security**: MySQL offers robust security features, including user authentication, data encryption, and access control mechanisms to protect data from unauthorized access.
- **Community and Ecosystem**: MySQL has a large and active community of developers and users who contribute to its development, provide support, and create extensions and plugins.
- **Storage Engines**: MySQL supports multiple storage engines, each optimized for different use cases. The most commonly used storage engine is InnoDB, known for its reliability and transaction support.
- **Applications**: MySQL is used in a wide range of applications, from small websites and personal projects to large-scale enterprise applications. It is often used in conjunction with web development languages like PHP, Python, and Ruby.
- **Administration Tools**: MySQL can be managed using various tools and interfaces, including command-line utilities, graphical user interfaces, and web-based tools like phpMyAdmin.
- **Replication and Clustering**: MySQL supports various replication techniques and clustering solutions to ensure data redundancy, high availability, and load balancing.

3.7.5. PHP (Hypertext Pre-processor)

PHP is a widely-used server-side scripting language designed for web development. It is an open-source, general-purpose scripting language that is particularly suited for creating dynamic and interactive web applications.

PHP has been a fundamental tool in web development for many years and continues to evolve with new features and improvements. It remains a popular choice for creating dynamic and interactive websites and web applications. (Luke Welling, Laura Thomson ISBN 10, 2020).

Here are some key aspects of PHP

- **Server-Side Scripting:** PHP is executed on the web server, not in the user's browser. When a user requests a web page that contains PHP code, the server processes the code and sends the resulting HTML to the user's browser. This allows for the creation of dynamic web content.
- **Embeddable in HTML**: PHP code is typically embedded within HTML documents using special delimiters (<?php and?>) to switch between HTML and PHP mode. This makes it easy to mix PHP code with HTML, making web development more flexible and dynamic.
- **Open Source**: PHP is open-source software, which means it is freely available, and developers can modify and redistribute it according to the terms of the PHP License.
- **Cross-Platform**: PHP is compatible with various operating systems, including Windows, Linux, macOS, and more. This makes it a versatile choice for web development on different server environments.
- **Database Integration**: PHP provides extensive support for working with databases, including MySQL, PostgreSQL, SQLite, and more. This makes it a popular choice for building database-driven web applications.
- **Large Ecosystem**: PHP has a vast ecosystem of libraries, frameworks, and tools that simplify common web development tasks. Popular PHP frameworks include Laravel, Symfony, and CodeIgniter.
- **Web Application Development**: PHP is often used to build web applications, content management systems (CMS), e-commerce websites, forums, blogs, and a wide range of other web-based software.
- **Community and Support**: PHP has a large and active community of developers who contribute to its development, share knowledge, and provide support through forums, tutorials, and documentation.
- **Security Considerations**: While PHP itself is not inherently insecure, the security of PHP applications depends on how they are developed. Developers must follow best practices to prevent common vulnerabilities, such as SQL injection and cross-site scripting (XSS).

3.7.6 phpMyAdmin

phpMyAdmin is a free and open-source web-based application written in PHP. It provides a graphical user interface (GUI) for managing and administering MySQL or MariaDB databases.

Key Features:

- **Database management**: Allows users to create, modify, and delete databases and database tables.
- **SQL query execution**: Enables users to run SQL queries and view query results in a user-friendly interface.
- **Data import and export**: Supports importing and exporting database data in various formats, such as SQL, CSV, and more.
- **User management**: Allows for the creation and management of database users and privileges.
- **Visual representation**: Provides visual representations of database structures and relationships.
- **Use Case**: Developers and database administrators use phpMyAdmin to simplify database management tasks, making it easier to interact with and maintain databases.

3.7.7 Apache HTTP Server (Apache);

Apache is one of the most widely used open-source web servers in the world. It is a web server software that serves web pages to clients (browsers) using the HTTP and HTTPS protocols.

Key Features

- **Web server functionality**: Apache serves static web content (HTML files, images, etc.) and can also handle dynamic content through modules and scripting languages like PHP, Python, and Perl.
- **Virtual hosting**: Supports hosting multiple websites on a single server, each with its own configuration and domain names.
- **Security:** Provides various security features and modules for protecting web applications and servers.
- **Extensibility:** Apache can be extended and customized through modules to add functionality such as authentication, URL rewriting, and more.
- **Use Case:** Apache is the go-to choose for hosting websites and web applications on Linux and Unix-like servers.

In a typical web development setup, Apache would be used as the web server to host websites and web applications, while phpMyAdmin might be used to manage the associated MySQL both Apache and phpMyAdmin are essential tools for web developers and system administrators when setting up and maintaining web servers and databases. They play a crucial role in the development and deployment of web applications.

3.8 System Requirements

System requirements are the minimum and/or maximum hardware and software specifications that a system or application must meet in order to function properly. a statement that identifies the functionality that is needed by a system in order to satisfy the customer's requirements. The statement should clearly explain what the customer exactly wants and how they want it. A customer's need might be satisfied, solve a problem, achieve an objective, meet a standard, or to meet any other guidelines of the project (https://www.umsl.edu, 2023).

3.8.1 Functional Requirements of Information System for Monitoring Vaccinations in Expectant Pregnant mothers and Children under Five Years

In Software engineering and systems engineering, a functional requirement defines Functional requirement as the product features or functions that developers must implement to enable users to accomplish their tasks. So, it's important to make them clear both for the development team and the stakeholders.

Generally, a function is described as a set of inputs, the behavior, and outputs and functional requirements specify particular results of a system. (Gerardus Blokdyk , 2021).

- Enabling the creation of new and valid user accounts.
- Validating login credentials provided by users.
- System must send a notification(reminder) to the patient for next vaccines
- Administrator must be able to view history of every patient who registered for vaccinations
- The system should generate different patients and vaccines reports accordingly.
- Nurse should be able to view and manage patient's vaccines' status.
- System must store information related to vaccines and the patients.
- The system must guarantee secure access to the stored data, managing the permissions according to the user profile.

3.8.2 Nonfunctional requirements

- The system should have a user-friendly interface that is easy to use.
- The system shall be accessible from anywhere in the world.
- The system should provide a high level of accuracy in its operations.
- The system shall be made available all the time, unless while system is under maintenance.

3.8.3 User requirement of the proposed system

Whenever a pregnant mother come to the health center/hospital at first time or if it is new born, the nurse must register him/her and only system administrator and nurse can register a patient in Vaccination Tracking Information System, therefore in this part, specific functions are described as below:

1. **Login and logout.**
    - Users should be able to securely log into or log out the system using their credentials.
2. **Registration and Authentication:**
    - Users should be able to register in the system to gain access to its features.
    - Required information for registration should be clearly specified
    - Proper authentication mechanisms should be implemented to ensure user privacy and data security.
    - Users should be able to securely log into the system using their credentials.

3. Patient Checks:

• Patients should have the ability to view various information within the System related to him/her vaccinations records, next appointments

• The system should provide accurate and reliable results based on the input provided by patients.

4. Nurse-Patient Interaction:

• Nurse should be able to view a list of patients available within the system.

• Nurses should have the option to search for specific patient based on its specialization or other criteria.

Nurses should be able to manage the appointment details of patients and canceling appointments if necessary.

• Patients should be able to manage their information about vaccines, including viewing individual vaccination report.

• Appointment details and cancelling appointments if necessary.

5. User Profiles:

• Patients should have personal profiles where they can browse and saw ther/his information.

• Nurses should also have profiles that display relevant details about their practice.

• User profiles should be customizable and allow users to manage their information effectively.

6. Feedback and Support:

• The system should provide a platform for patients to provide feedback regarding their needs.

• Feedback should be easily accessible for administrators to review and take necessary actions.

• Users should have access to support channels to address the issues or queries they may have.

7. Admin Privileges:

• Administrators should have the ability to manage Nurses, including adding, editing, deleting, and searching for Nurse in the system.

• Similarly, administrators should be able to manage patients, with functionalities for viewing, and searching patient records.

3.8.4 Core Modules or Features:

1. User Registration and Authentication
2. Login and Logout.
3. Patient Checks
4. Nurse-Patient Interaction and Appointment Management
5. User Profile Management
6. Feedback and Support
7. Admin Privileges for Nurse and Patient Management

3.8.5 Requirement specification

Hardware specifications

- Computer such as HP, Dell, Mac, etc.
- Processor: Intel core i3 or higher
- RAM: Minimum requirement of 8GB

Software specifications

Client-side specifications:

Operating system Windows 10 and above, android phone with android version 8 or above, ios12 or above

Server-side specifications:

Back-End Tool: Structured databases like MySQL 8.x, PHP-8.2, JavaScript, windows-x64, HTML-5 and CSS-3.

3.9 Use Case Diagram

A use case diagram is a dynamic representation of system functionality in the Unified Modeling Language (UML). It illustrates the interactions between actors (roles) and use cases (actions) within a system. Use cases represent a series of steps that describe how a role interacts with the system to achieve a specific goal. These diagrams provide a graphical representation of the relationships and interactions among system elements.

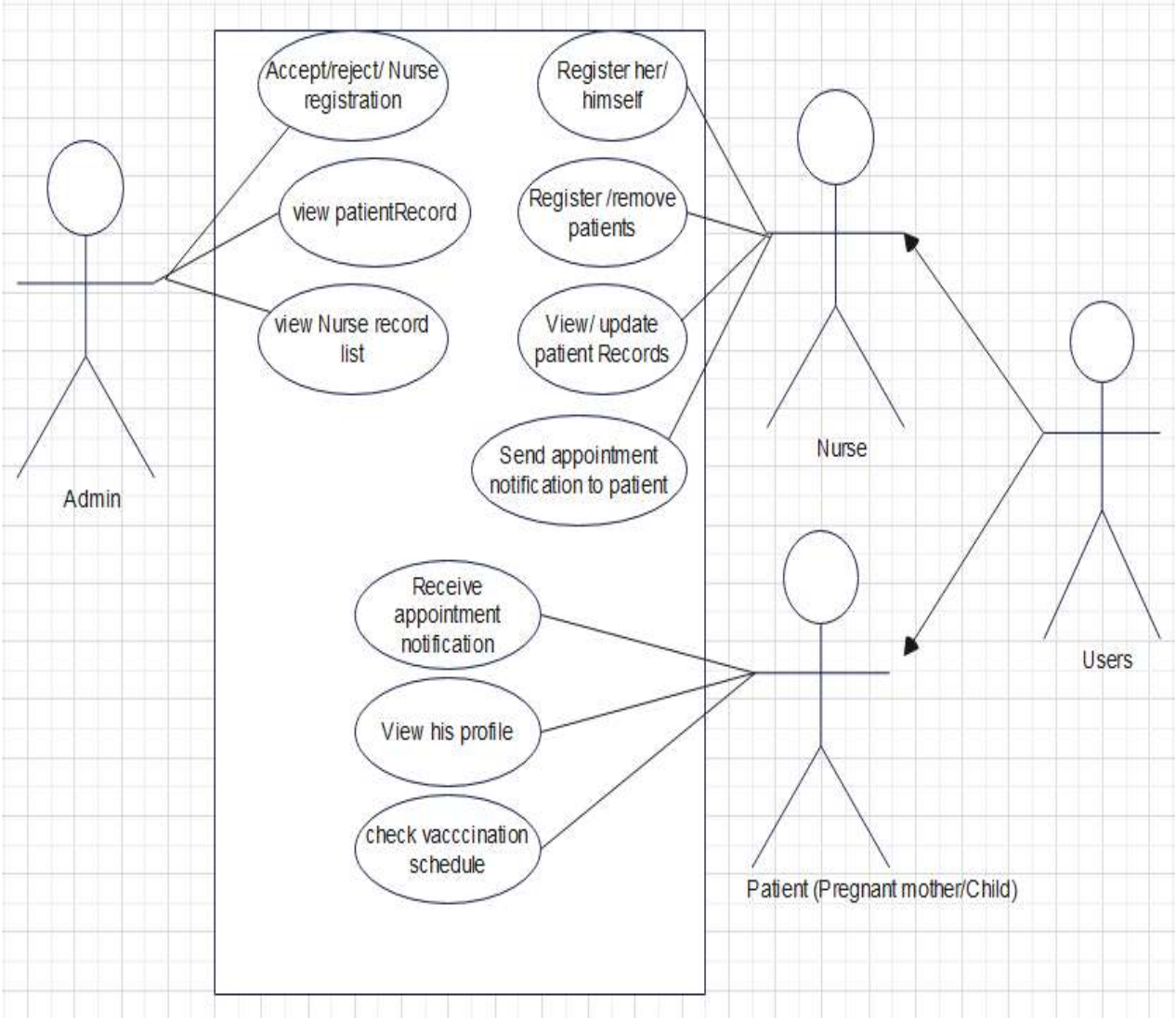


Figure 4: ***Use case Diagram of Information System for Monitoring Vaccinations in Expectant Pregnant mothers and Children under Five Years.***

Source:**(Researcher own design 2023)**

In my system, the actors are the admin, patient, and Nurse Each actor play a distinct role within the system. The use case diagram visually depicts the desired functionality of the system. For patients, the use case diagram shows that they check vaccination schedule in the system, view his profile, and receive appointment notification. For Nurse can login, register/remove patient, view a list of patients, send appointment notification for confirmation or next vaccination schedule and view or update patient records, search for specific patient, manage the appointment means that nurse can view appointment details, add, edit, delete, cancel.

The admin role has additional privileges, including managing nurses (add, edit, delete, search) and managing patients (view, search). The use case diagram provides a comprehensive overview of the system's functionality, showcasing the interactions between actors and the actions they can perform. It serves as a guide for understanding the system's behavior and helps guide the development and operation of the system.

3.10 Systems Design

3.10.1 Context Diagram

A context diagram, also known as a system context diagram or a level 0 DFD (Data Flow Diagram), is a visual representation that illustrates the scope and boundaries of a system or process. It is a high-level view that provides an overview of how a system interacts with its external entities showing the exchanges of data or information between them. Context diagrams are often used to depict the context of a system or process and help stakeholders understand the system's interactions with the outside world.

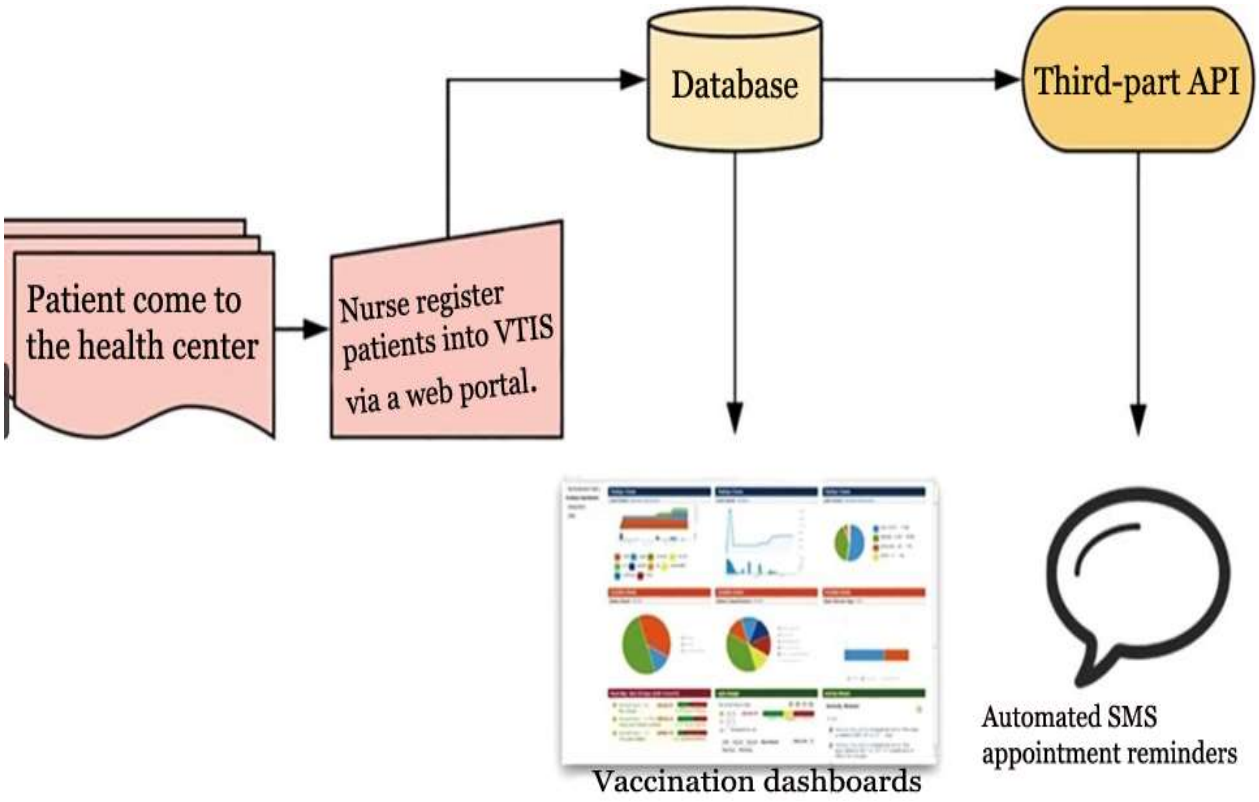


Figure 5: ***Context Diagram***

Context Diagram (own design 2023).

3.10.2 Data Flow Diagram

3.10.2.1 Definition

A data flow diagram (DFD) is diagram that explains how data is processed and transferred in a system. Means that a graphical or visual representation using a standardized set of symbols and notations to describe a business's operations through data movement. A level 1 DFD represents the main functions of the system and how they interact with each other mean that notates each of the main sub-processes that together form the complete system.

It uses defined symbols like rectangles, circles and arrows, plus short text labels, to show data inputs, outputs, storage points and the routes between each destination. It is an important technique for modelling a system's high-level detail by showing how input data is transformed to output results through a sequence of functional transformations.

It is useful for analyzing existing as well as proposed system and It provides an overview of what data is system processes, what transformation are performed, what data are stored. what results are produced, etc. Data Flow Diagrams show the flow of data from external entities into the system, and from one process to another within the system.

3.10.3 Concepts

3.10.3.1 Actor

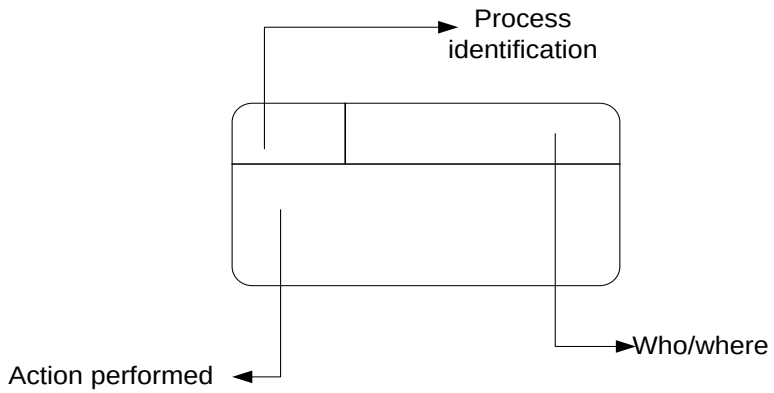
It is an element material or immaterial which can act in the system to be developed it can be external or internal according to its location inside or outside the organization which needs the system. There are four symbols for drawing a DFD:

- Rectangles representing external entities, or internal entities which are sources or destinations of data

If actor is a human being, internal actor if actor is human being, external actor

3.10.3.2. Process

- The processes take data as input, validate and process it and output it.



3.10.3.3 Data Flow

An arrow on a DFD that represents data movement among processes, data stores, and external agents 

- Arrows representing the data flows, which can either, be electronic data or physical items.

3.10.3.4 Data Stores

A data store is a data repository of a set of integrated objects. These objects are modelled using classes defined in database schemas. Data store includes not only data repositories like databases; it is a more general concept that includes also flat files that can store data. Data Stores are repository for data that are temporarily or permanently recorded within the system. It is an "inventory" of data. These are common link between data and process models. Only processes may connect with data stores. Data store are represented by Narrow opened rectangle as follows.

- Open-ended rectangles representing data stores, including electronic stores such as databases or XML files and physical stores such as filing cabinets or stacks of paper.

E.g. an information system is a system data.

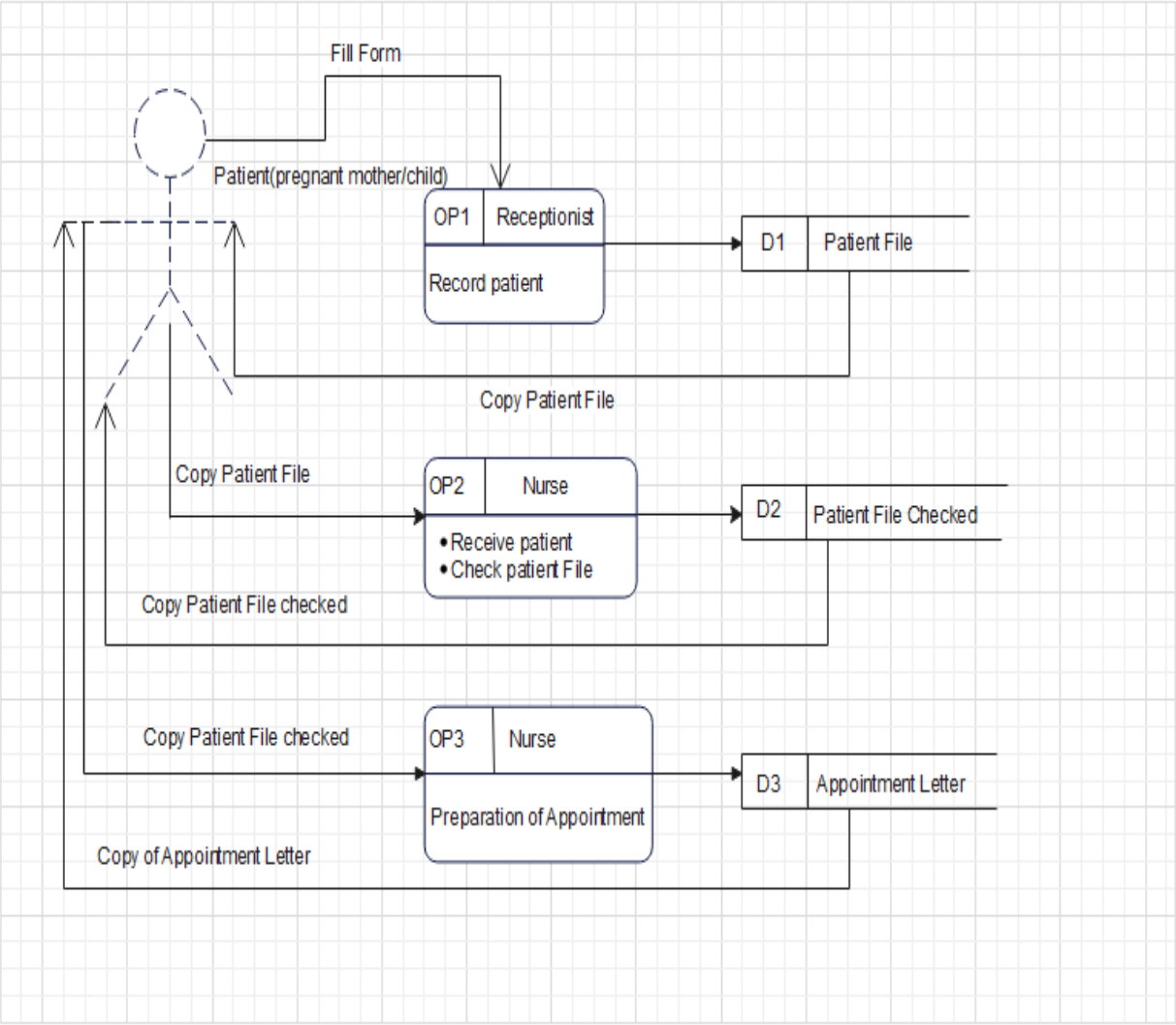


Figure 6: ***Data Flow Diagram Level 1 of Appointment***

Data Flow Diagram Level 1 of Appointment (Own design, 2023c).

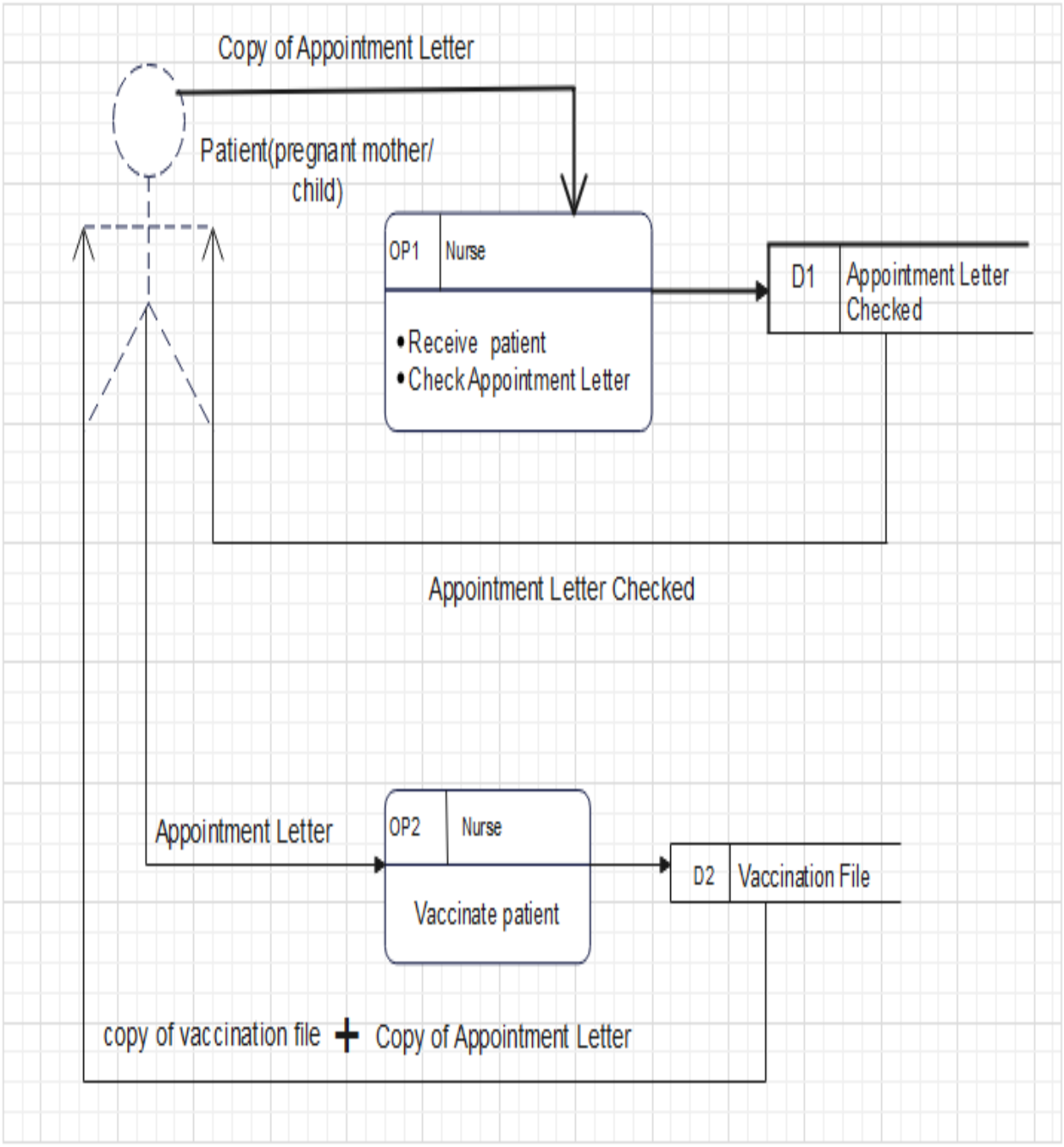


Figure 7: ***Data Flow Diagram Level 1 of Vaccination***

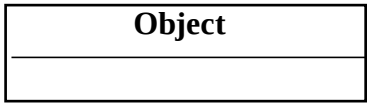
Data Flow Diagram Level 1 of Vaccination (Own design, 2023c).

3.10.4 Entity relationship diagram

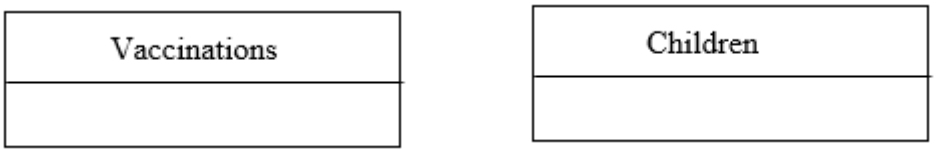
An entity relationship diagram (ERD) is a visual representation used to depict the structure of a database, means that shows the relationships of entity set stored in a database. An entity in this context is a component of data, means that ER diagrams illustrate the logical structure of databases. It is the specialized symbols, and the meanings of those symbols, that make it unique. There are main components of an ERD:

3.10.4.1 Concepts

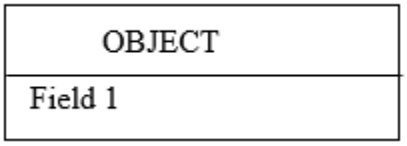
- **Entities:** which are represented by rectangles. These are objects or concepts that represent real-world items or concepts, typically corresponding to database tables. For example, in a database for **vaccination**, entities might include vaccines, children, appointments,



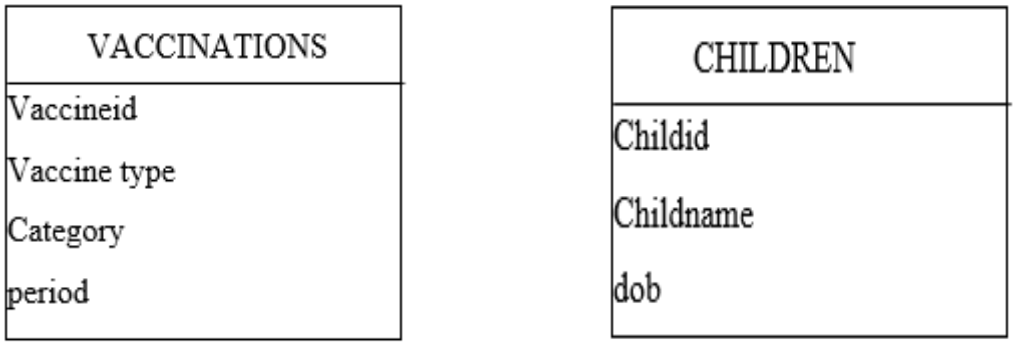
Example



- **Attributes**: a field or an Attributes which are represented by ovals, describe properties or characteristics of entities. For instance, vaccines entity, attributes could be "type"," purpose".
- **Field:** it is an attribute or article or propriety which characterised an object.



Examples:



- **Relationships:** These define how entities are connected or associated with each other. Relationships can be one-to-one, one-to-many, or many-to-many. They are represented by lines connecting the entities, with labels indicating the nature of the relationship.

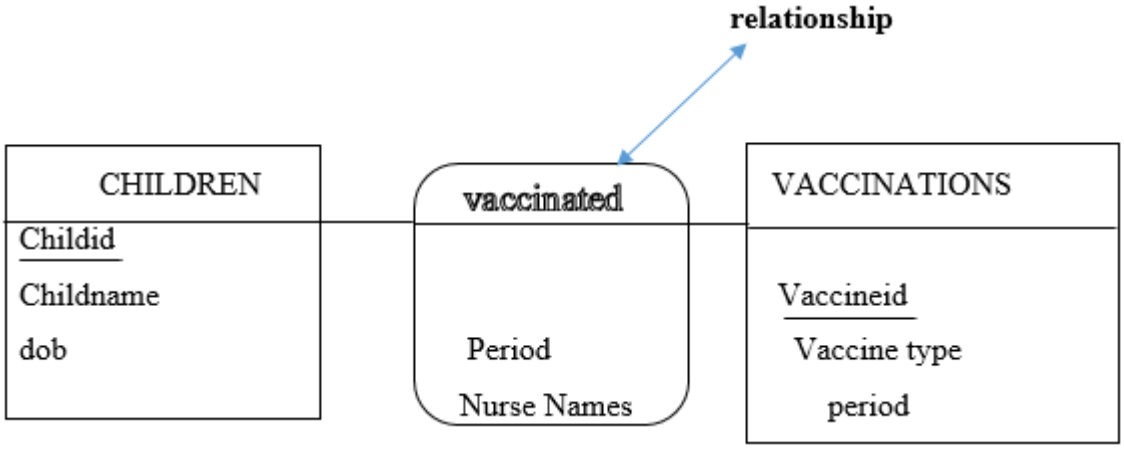


Figure 8: ***Relationship***

- **Cardinality:** Cardinality defines the number of instances of one entity that can be related to another entity. Common cardinality notations include "1" (one), "0..1" (zero or one), "1.." (one or more), and "0.." (zero or more).

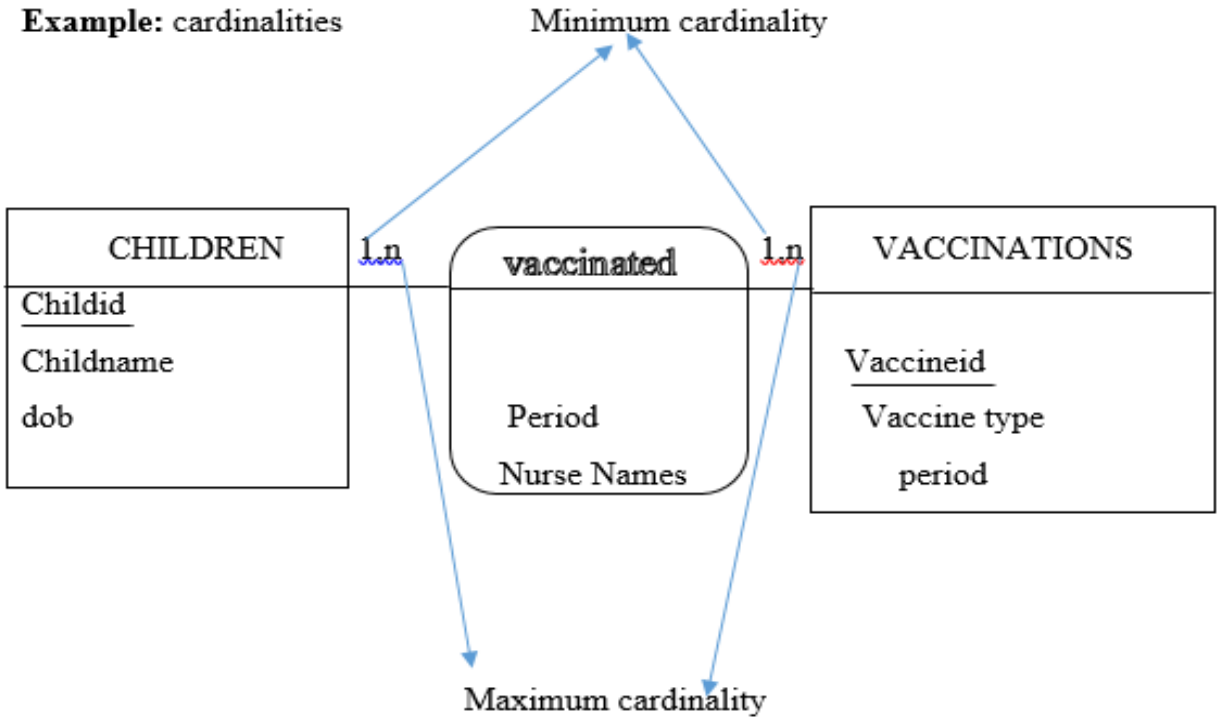


Figure 9: **Cardinality**

- **Connecting lines:** solid lines that connect attributes to show the relationships of entities in the diagram.
- **A key attribute**: is the unique, distinguishing characteristic of the entity
- **Field:** it is an attribute or article or propriety which characterised an object

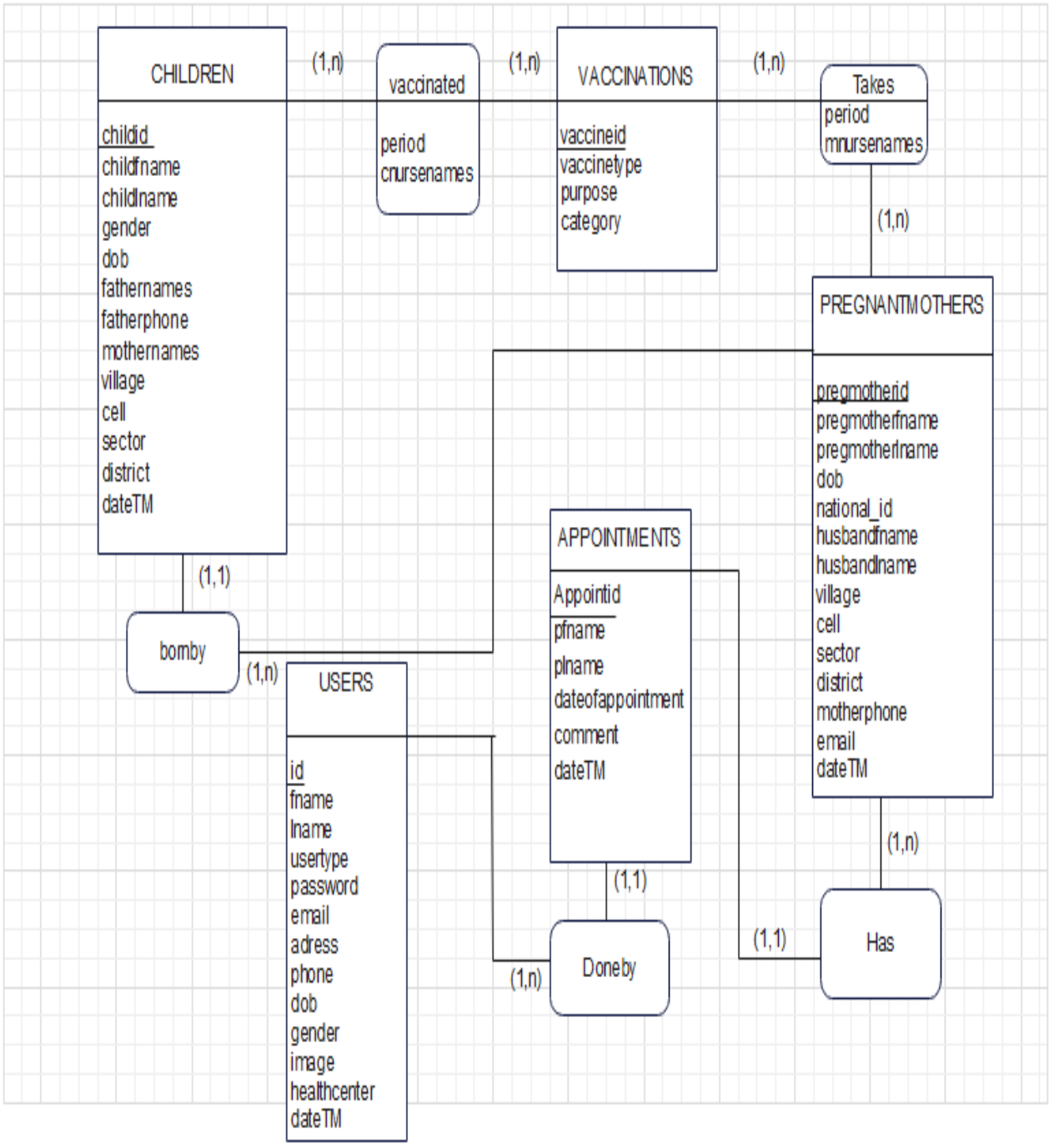


Figure 10: ***Entity Relationship Diagram***

Entity Relationship Diagram of Vaccination Tracking Information System (Own design, 2023d).

3.10.5 Physical Data Model (PDM)

Physical data model represents how the model will be built in the database. A physical database model shows all table structures, including column name, column data type, column constraints, primary key, foreign key, and relationships between tables. A physical data model can be used to generate DDL (Data Definition Language) statements which can then be deployed to a database server.

3.10.5.1 Features of a physical data model include:

- Specification all tables and columns.
- Foreign keys are used to identify relationships between tables.
- Normalization or Denormalization may occur based on user requirements.
- Physical considerations may cause the physical data model to be quite different from the logical data model.
- Physical data model will be different for different RDBMS. For example, data type for a column may be different between MySQL Postgresql, MongoDb .

3.10.5.2 The steps for physical data model design are as follows:

1. Convert entities into tables.
2. Convert relationships into foreign keys.
3. Convert attributes into columns.
4. Modify the physical data model based on physical constraints / requirements

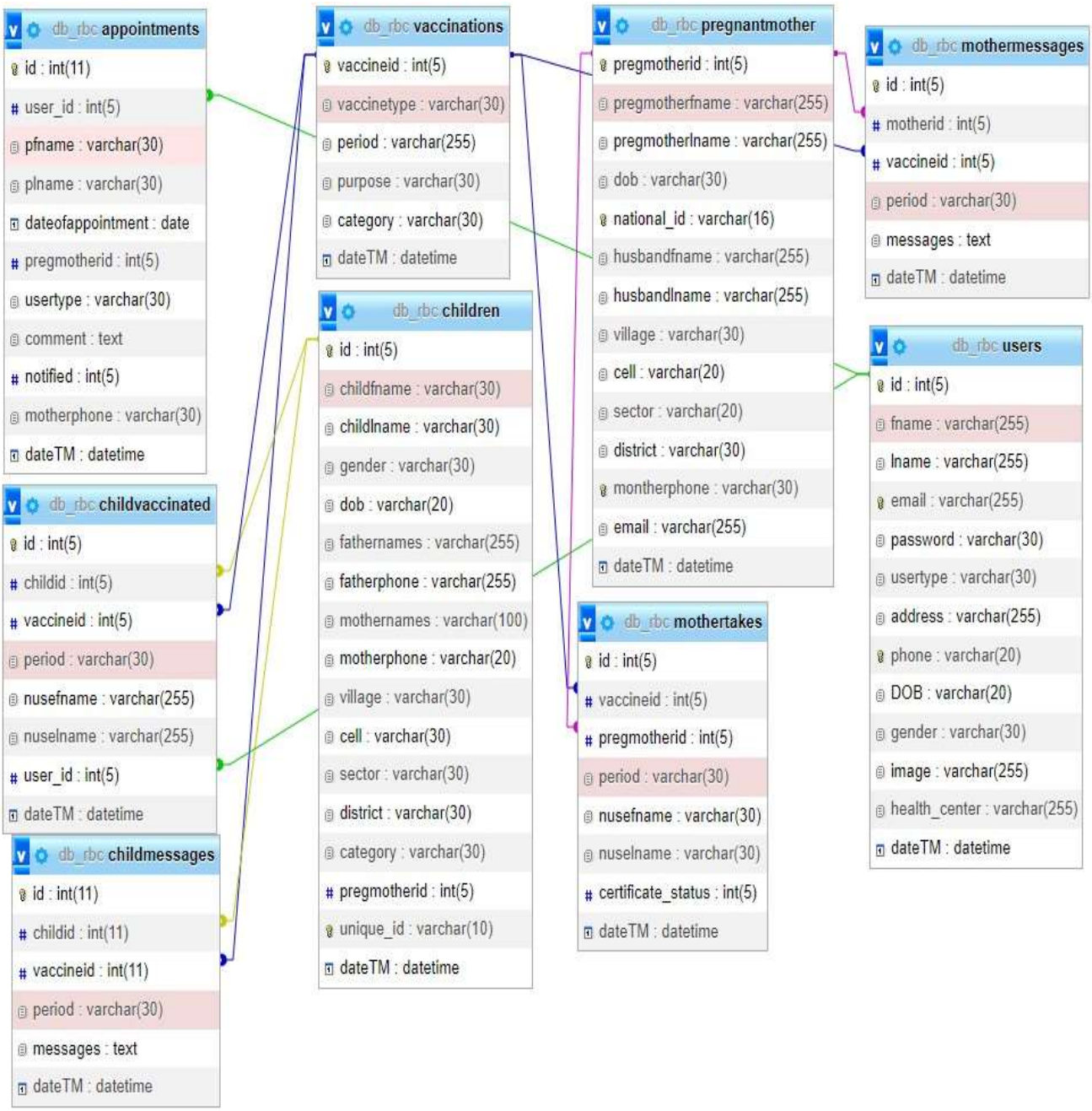


Figure 11*: Physical Data Model*

Physical Data Model of Vaccination Tracking Information System (Own design,2023).

3.10.6 Data dictionary (DD)

3.10.6.1 Definition

A data dictionary is a file or a set of files that contains a database's metadata. The Data dictionary is a collection of descriptions of the data objects or items in a data model to which programmers and others who need to refer to it. A first step in analyzing a system of objects with which users interact is to identify each object and its relationships to other objects. This

process is called “data Modeling” and results in a picture of object relationships. After each data object or item is given a descriptive name, its relationship is described (means that it becomes part of some structure that implicitly describes relationship), the type of data (such as text or image or binary value) is described, possible predefined values are listed, and a brief textual description is provided. This collection can be organized for reference into a book called a data dictionary. The data dictionary is a crucial component of any relational database.

3.10.6.2 Representation of Data Dictionary

Table 4*:Data Dictionary of child*

#	Name	Type	Collation	Attributes	Null
1	id	int(5)			No
2	childfname	varchar(30)	utf8mb4_general_ci		No
3	childlname	varchar(30)	utf8mb4_general_ci		No
4	gender	varchar(30)	utf8mb4_general_ci		No
5	dob	varchar(20)	utf8mb4_general_ci		No
6	fathernames	varchar(255)	utf8mb4_general_ci		No
7	fatherphone	varchar(255)	utf8mb4_general_ci		No
8	mothernames	varchar(100)	utf8mb4_general_ci		No
9	motherphone	varchar(20)	utf8mb4_general_ci		No
10	village	varchar(30)	utf8mb4_general_ci		No
11	cell	varchar(30)	utf8mb4_general_ci		No
12	sector	varchar(30)	utf8mb4_general_ci		No
13	district	varchar(30)	utf8mb4_general_ci		No
14	category	varchar(30)	utf8mb4_general_ci		Yes
15	pregmotherid	int(5)			Yes

Table 5*: Data Dictionary of user*

#	Name	Type	Collation	Attributes	Null
1	id	int(5)			No
2	fname	varchar(255)	utf8mb4_general_ci		No
3	lname	varchar(255)	utf8mb4_general_ci		No
4	email	varchar(255)	utf8mb4_general_ci		No
5	password	varchar(30)	utf8mb4_general_ci		No
6	usertype	varchar(30)	utf8mb4_general_ci		No
7	address	varchar(255)	utf8mb4_general_ci		No
8	phone	varchar(20)	utf8mb4_general_ci		No
9	DOB	varchar(20)	utf8mb4_general_ci		No
10	gender	varchar(30)	utf8mb4_general_ci		No
11	image	varchar(255)	utf8mb4_general_ci		Yes
12	health_center	varchar(255)	utf8mb4_general_ci		No
13	dateTM	datetime			No

Table 6*: Data Dictionary of Appointment*

#	Name	Type	Collation	Attributes	Null
1	id	int(11)			No
2	user_id	int(5)			No
3	pfname	varchar(30)	utf8mb4_general_ci		No
4	plname	varchar(30)	utf8mb4_general_ci		No
5	dateofappointment	date			No
6	pregmotherid	int(5)			No
7	usertype	varchar(30)	utf8mb4_general_ci		No
8	comment	text	utf8mb4_general_ci		Yes
9	notified	int(5)			No
10	motherphone	varchar(30)	utf8mb4_general_ci		No
11	dateTM	datetime			No

CHAPTER 4: SYSTEM IMPLEMENTATION

4.1 Introduction

In this chapter, I deeply present the tools and technologies used for implementing this system" Vaccination Tracking Information system". In this chapter, I demonstrate the output of the new system, how it works, and how it will solve different problems.

4.2 Tools and languages that are used in the software development

- Computer operating system: Windows 10
- Web browser Google Chrome, Opera, fire fox
- Front end languages: HTML, CSS, JavaScript
- Server-side languages: PHP
- Database: MySQL
- Database GUI tools: PHPmyaAdmin, Apache.

4.2.1 PHP (Hypertext Preprocessor)

It is a widely-used server-side scripting language encoded with HTML and designed for web development. It is an open-source, general-purpose scripting language that is particularly suited for creating dynamic and interactive web applications.

4.2.2 phpMyAdmin

phpMyAdmin is a free and open-source web-based application written in PHP and it provides a graphical user interface (GUI) for managing and administering MySQL.

4.2.3 Apache HTTP Server (Apache)

It is one of the most widely used open-source web servers in the world. It is a web server software that serves web pages to clients (browsers) using the HTTP and HTTPS protocols.

4.2.4 MySQL

MySQL is an open-source relational database management system (RDBMS) that is widely used for managing and storing structured data. It is one of the most popular database systems in the world and is known for its reliability, scalability, and performance.

4.2.5 HTML

HTML, which stands for **Hyper Text Markup Language**, is the standard markup language used to create web pages and display content on the World Wide Web. It is the backbone of web development and is used to structure content and define the layout of web pages

4.2.6 JavaScript

CSS, which stands for Cascading Style Sheets, is a stylesheet language used in web development to control the presentation and layout of HTML documents. CSS allows web developers and designers to define how web content should be displayed, including its appearance, positioning, colors, fonts, and more

CSS is a fundamental technology in web development and plays a crucial role in creating visually appealing, user-friendly, and responsive websites. It complements HTML and JavaScript, allowing web developers to craft engaging and well-designed web experiences.

4.2.7 JavaScript

JavaScript is a versatile and widely-used programming language primarily used for web development, but it has expanded its presence to various other application domains.

JavaScript is a fundamental language for web development and is essential for creating modern, interactive, and dynamic web applications. Its versatility, large ecosystem of libraries and frameworks, and widespread support make it a valuable skill for web developers and programmers in various domains.

4.3. System implementation

System implementation is an important phase in the software development life cycle. Web based Vaccination Tracking Information System is implemented on Windows operating systems. In the system implementation stage, the newly developed system is delivered to the users, organization after proper and adequate testing.

System implementation encompasses series of stages, and each of these stages is essential to the successful implementation of any system. The implementation stage is carried out in the following aspects:

1. Defining how the information system should be built (i.e., physical system design),
2. Ensuring that the information system is operational and used,
3. Ensuring that the information system meets the quality standard (i.e., quality assurance).

4.3.1 Software Testing

Software testing is a critical phase in the software development lifecycle (SDLC) that involves evaluating a software application to identify and rectify defects, bugs, and issues. The primary purpose of software testing is to ensure that the software meets its specified requirements, functions correctly, and is of high quality before it is released to users or customers. Testing helps to enhance the reliability, performance, security, and usability of software products.

4.3.1.1 Integration Testing

Integration testing is a level of software testing where individual components or modules of an application are combined and tested as a group to ensure that they work together as intended. The primary objective of integration testing is to detect any inconsistencies, errors, or issues that may arise when different parts of the software interact with each other.

The Purpose of Integration testing is to verify the interactions and interfaces between various components, modules, or subsystems within a software application. It helps ensure that these components can work together harmoniously to deliver the desired functionality.

4.3.1.2 View Testing

View testing refers to View model testing whereby it shows the whole process that the user of the system follow from the beginning until data is viewed from the database to the report, and that process starts from the login interface where the user enters the username and password and click on login therefore when the username or password is wrong the user will receive an error message that tells him/her to enter the correct username and password. When it is correct then the main menu interface appears where there are all links of the interfaces(pages). Here the user who has the privilege of Nurse wants to view the details of vaccinated children then she/he click on vaccinated children report and if the report appears respond as expected, the testing is done.

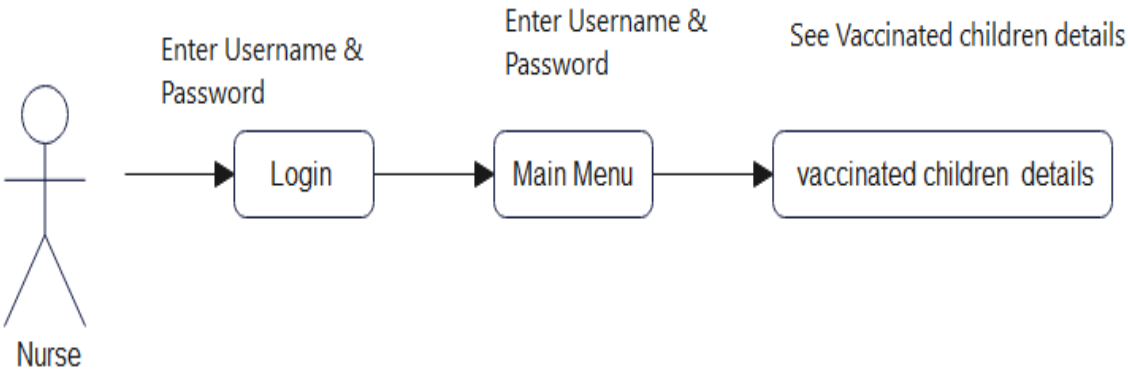


Figure 12: ***View model Testing***

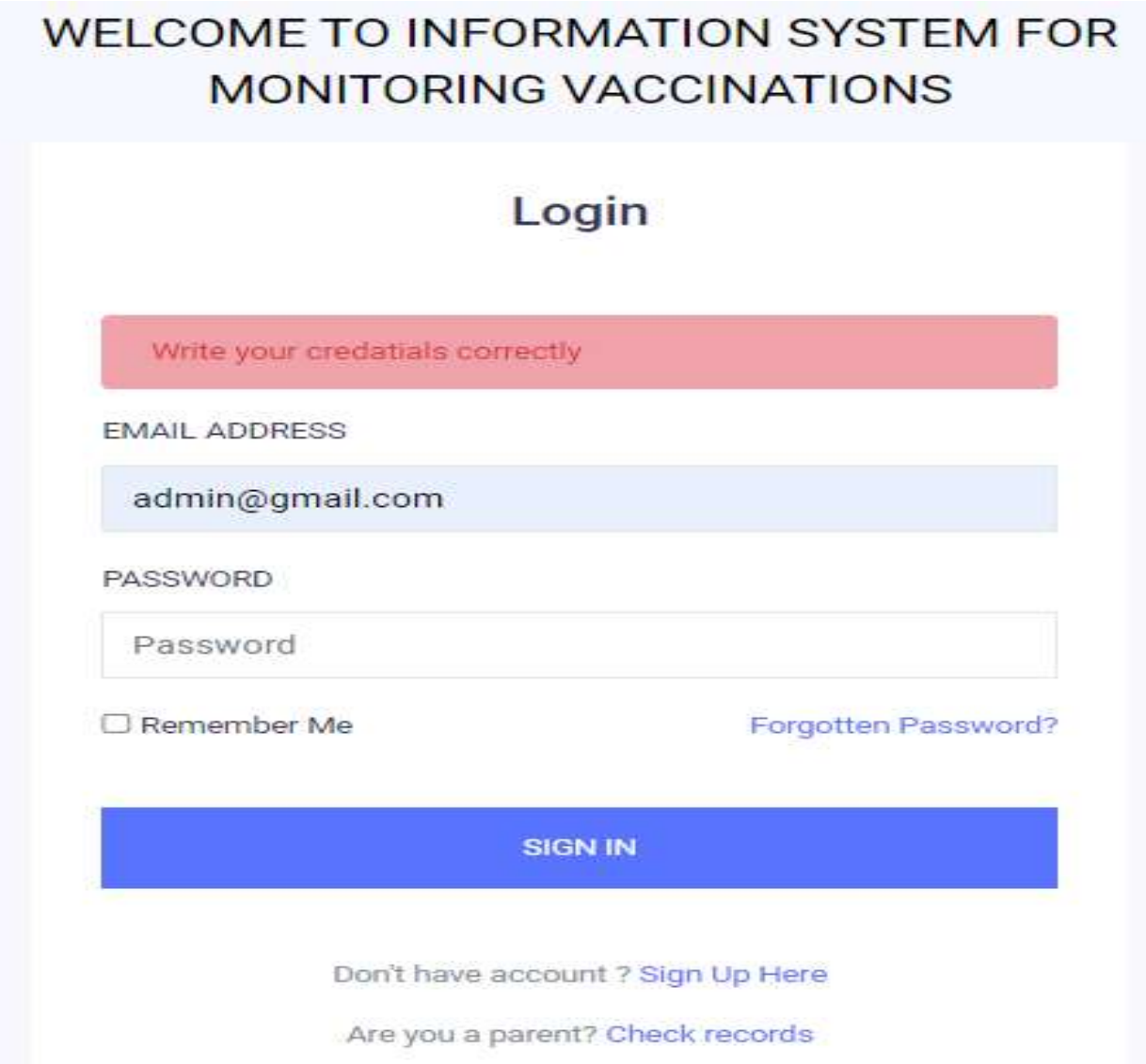


Figure 13: **Password message box**

4.3.1.3 Effectiveness and Reliability Testing

Vaccination Tracking Information System fulfill the desired expectation of the user and delivers the desired results when used in a real-world context.

This is used to show the system will be performing after testing on all forms and reports whereby for example you can search any vaccinated child or pregnant woman, you can print any wanted report, save any record in desired form, the system notifies the patient (pregnant mother/child) for next vaccine and remind her/ him.

Therefore, the system produces intended result accurately and because it is User friendly, the users must be well trained by the developer of the system (INFORMATION SYSTEM FOR MONITORING VACCINATIONS) in order to be aware of the system and to be productive at work.

4.3.2. Screenshots of a running system

The following interface is a login page where any user can view it without authentication. The system's administrator can login and register nurses in order to have credentials to perform different operations relating to the patients. Each user has Username and Password then login as his/her privileges to perform the required tasks.

Login Page

The login interface is interface that enable the user to enter into the system by entering username and password, this is for the security purpose to prevent anybody to perform any tasks without permission. As the privileges of users (Admin, Nurse and patient) are different from each other here in **Figure 14,** the user called Nurse he/she register him/herself (Sign Up) and after registration she /he login into the system if the credential (username & password) are correct she/he directly enters into the system with all privileges of Nurse, otherwise the system will reject that user.

Also if user is forgotten Password he/she can reset that password and parent can check the status of previous vaccines of his children (Check records). All those features are shown in Figure 14 below:

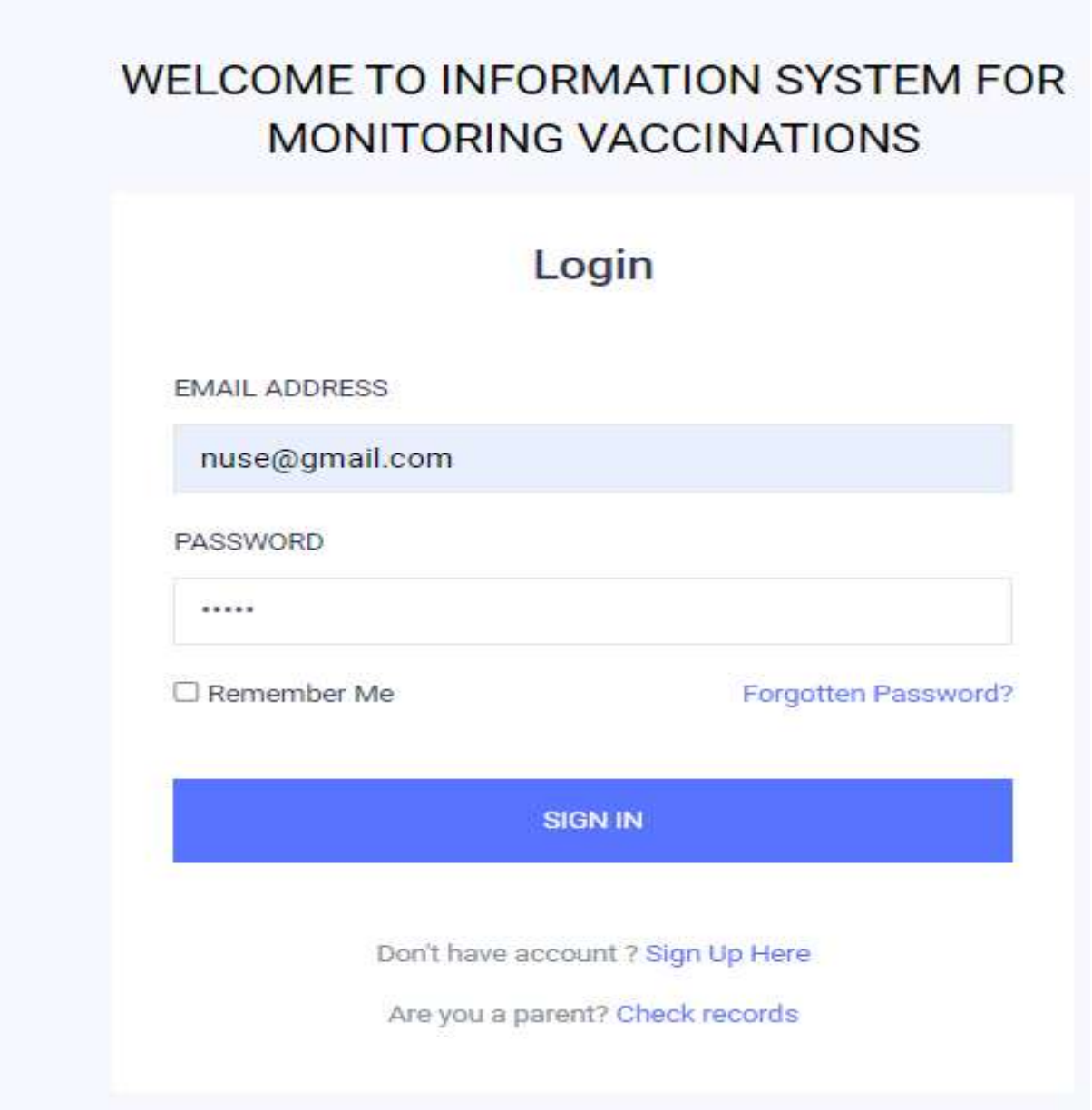


Figure 14: ***Login Page***

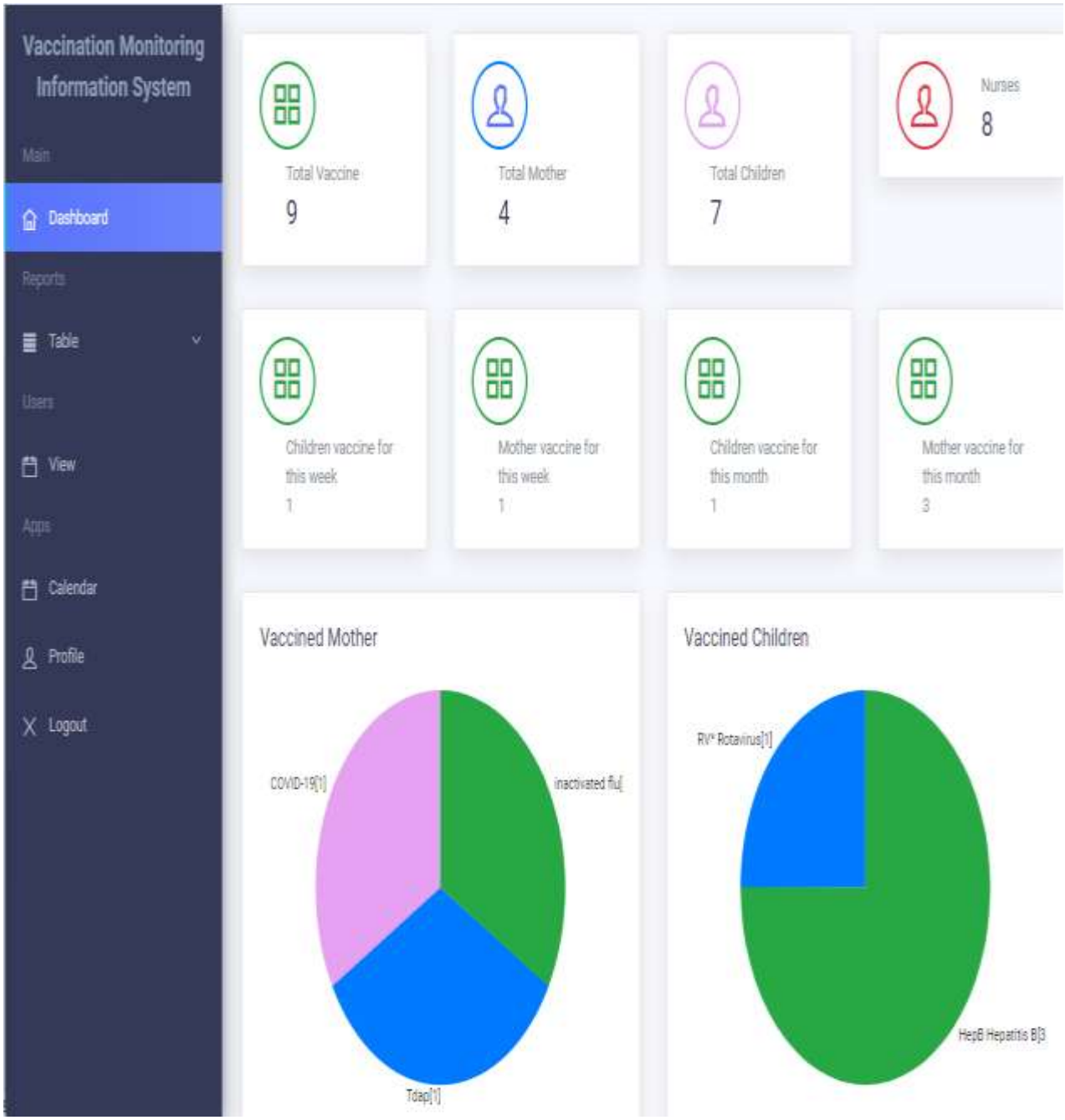


Figure 15: ***Home page of Admin***

Figure 15 shows the dashboard of Admin as a user who have the privileges of admin and he can view all tables of system means that Children records, pregnant mother record, vaccinated children record, vaccinated pregnant mother's records but he cannot change those information of patients and also he can edit the information of Nurse only.

Registration Form for Nurse

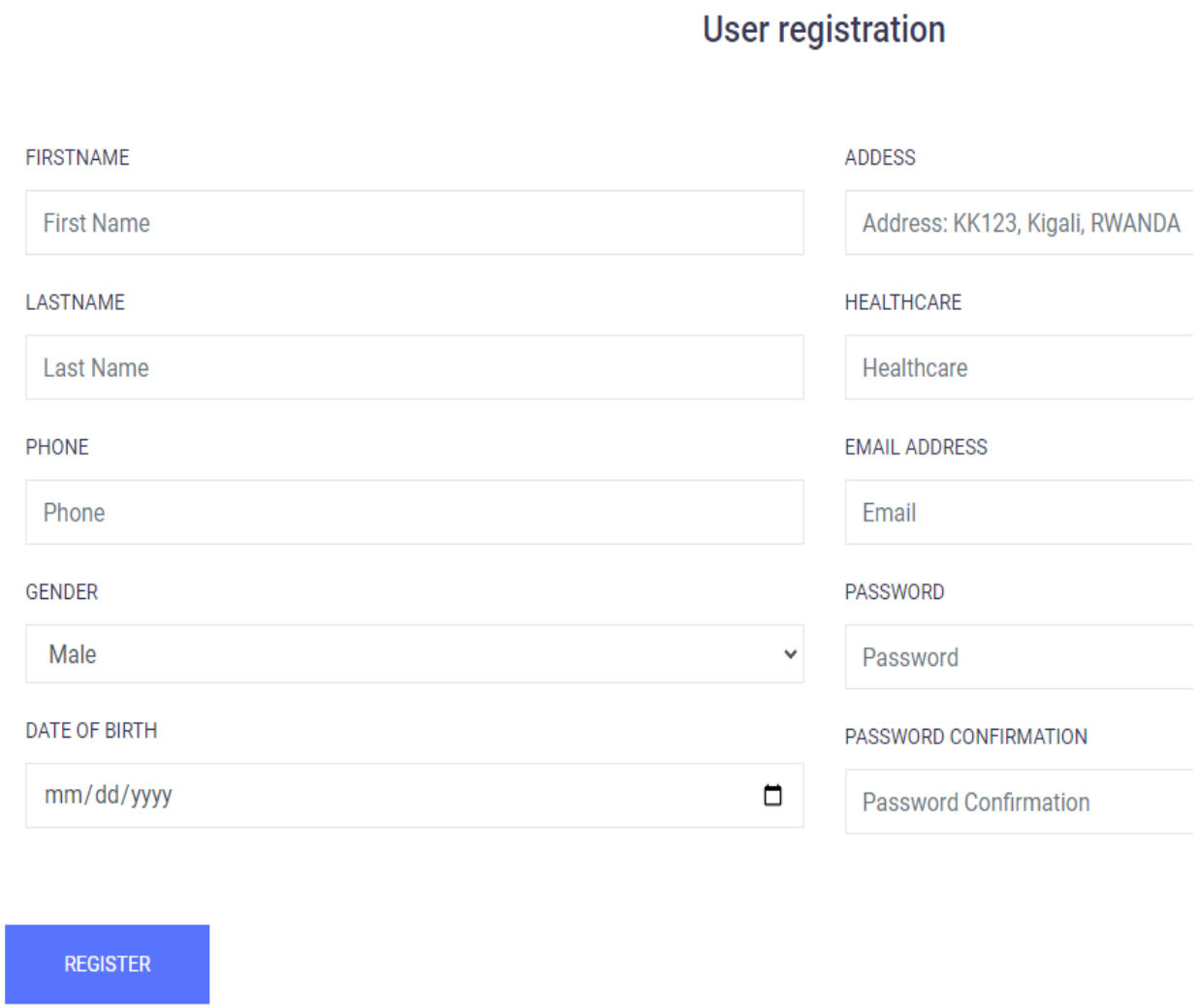


Figure 16: ***Registration Form for Nurse***

For Figure 16, Nurse can register her/himself or Admin can register the Nurse and by clicking to Sign Up, the user registration Form appears for allowing nurse to register himself or admin can also register the nurse. And directly information goes into system. therefore, Nurse can login using his credentials.

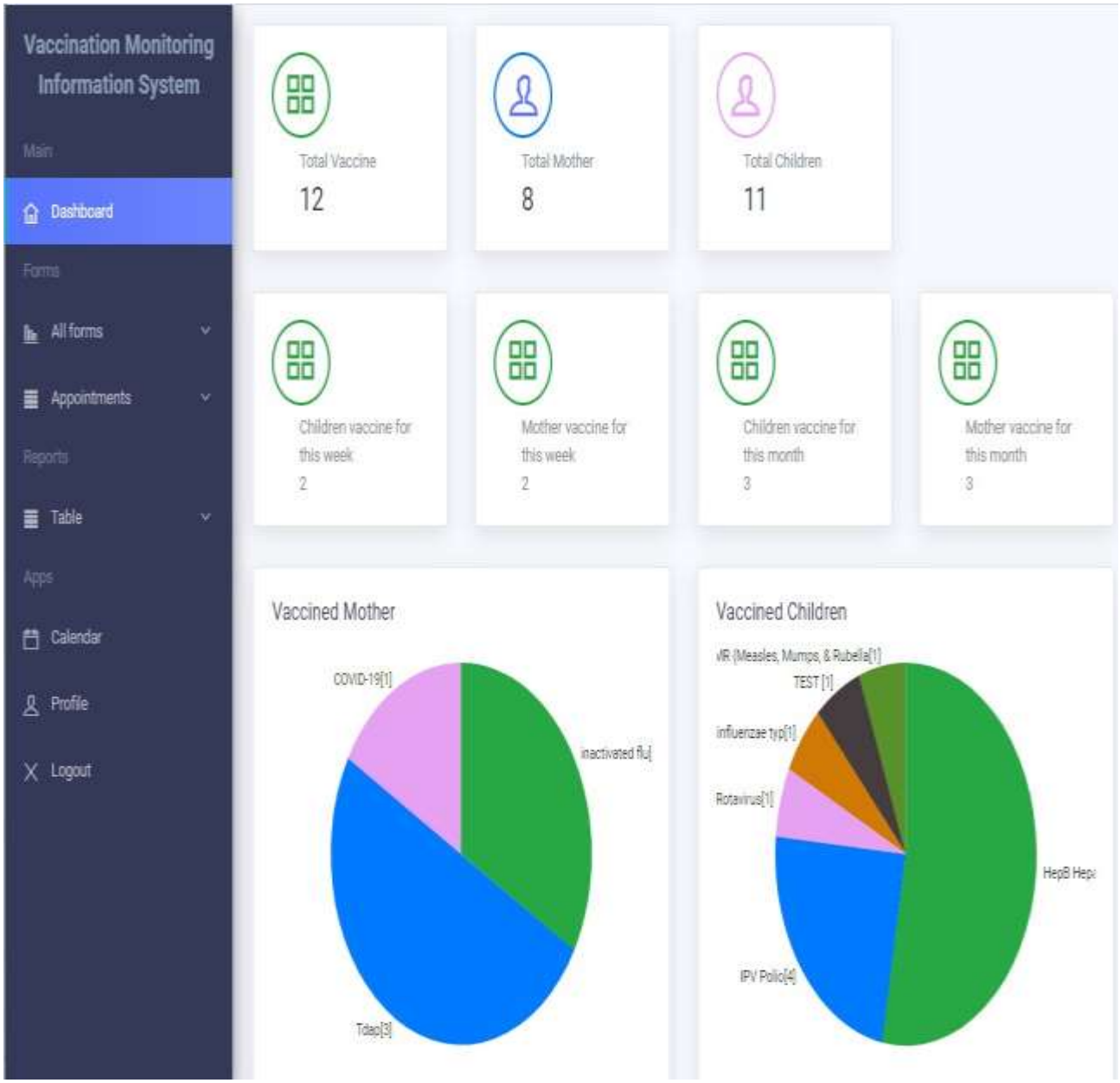


Figure 17: ***Home Page of Nurse***

For figure 17 shows that the Nurse can register, update or delete the patient records and give an appointment, by the time the system automatically can generate the total number of the patient who will come to the health care to take next vaccine within that week or that months Also nurse can manage the stock of vaccines that have given to the patients in order to be prepared in shortage of vaccines or other analysis relating to the vaccinations stock.

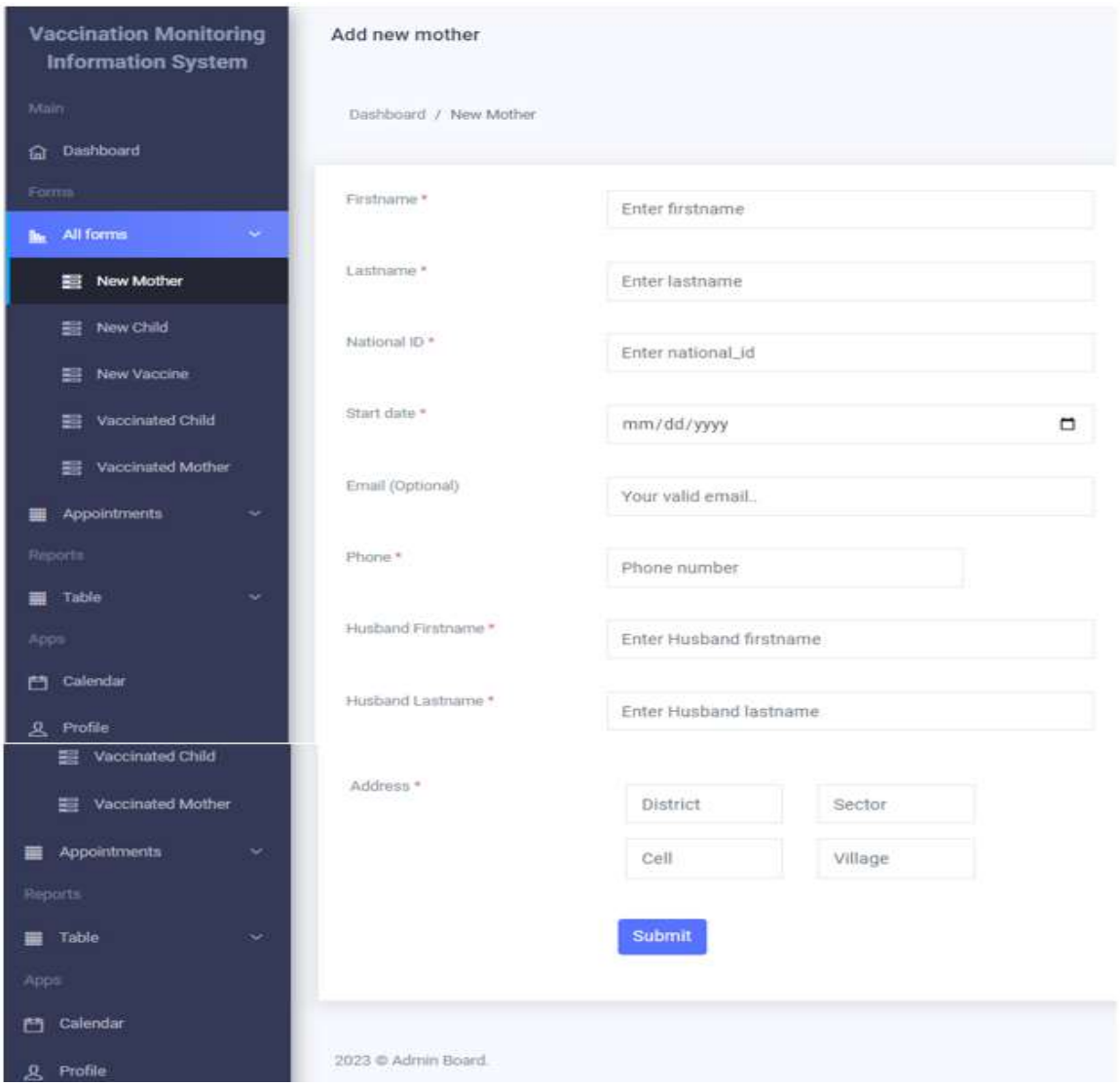


Figure 18: ***Registration Form for pregnant Mothers***

Figure 18 shows the details needed in Registration of pregnant women and unique identification for pregnant women is National ID or passport.

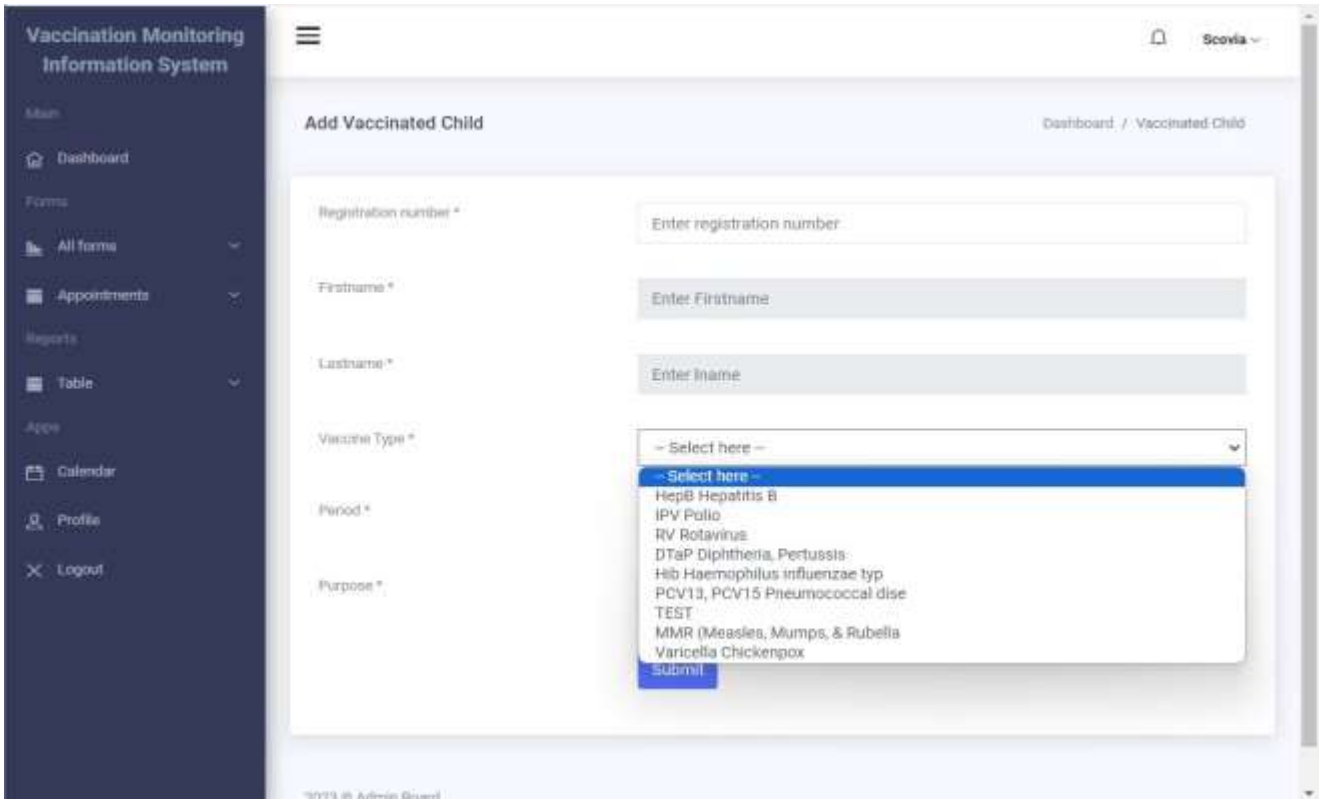


Figure 19: ***Vaccinated Child Interface***

Figure 19 shows that if a patient came to take the vaccine to the healthcare, the nurse gives patients, the vaccine depend on the appointment that patient has, then nurse record that types of vaccine that patient takes and if the patient has taken that vaccine, the system will refuse to record that types of vaccine and it gives a message to the nurse that type of vaccines patient has already taken.

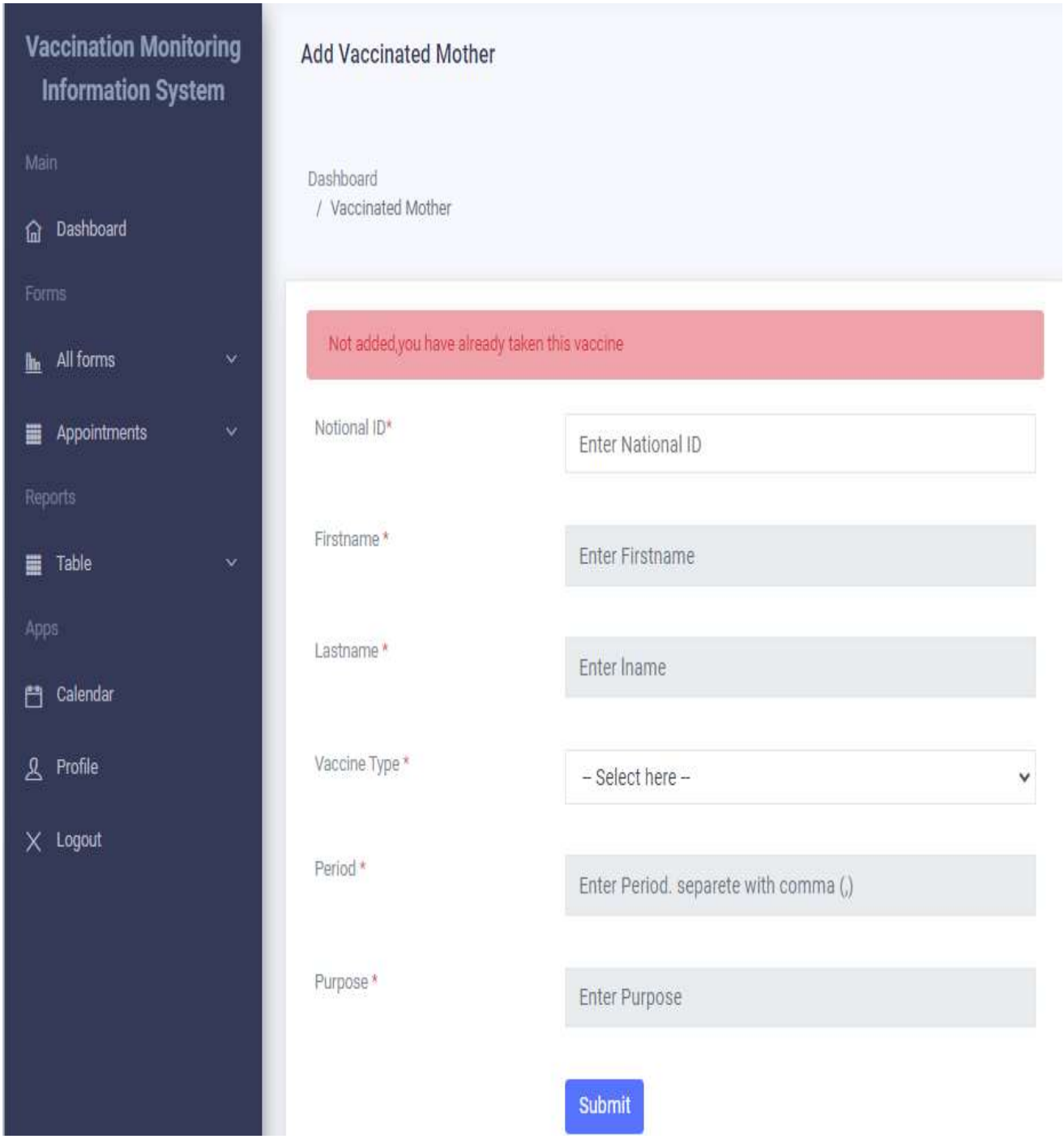
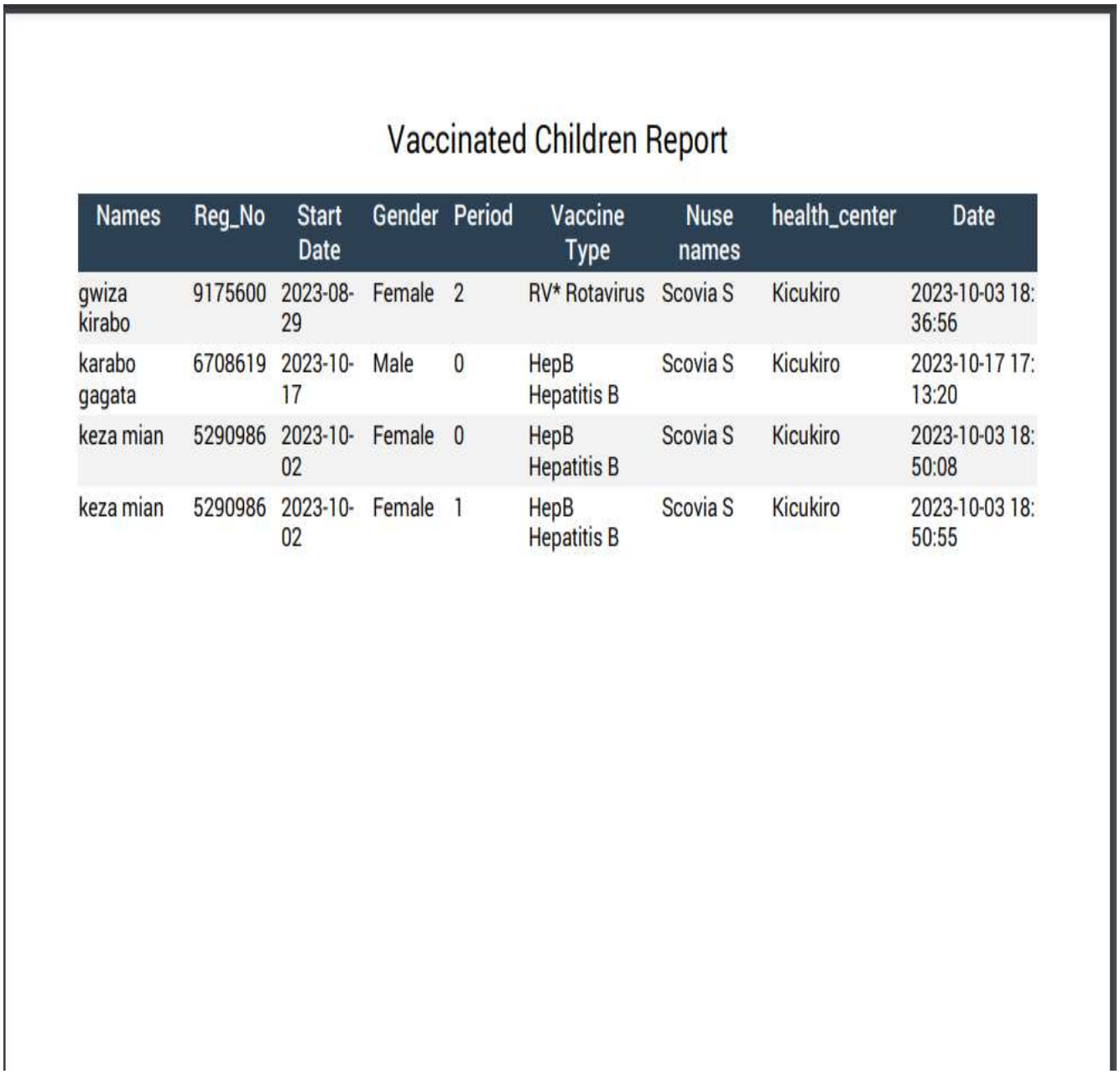


Figure 20: ***The message that prevents the nurse from giving an overdose to the patient.***

For Figure 19 shows that if the patient (child/pregnant mother) took all intended vaccines, the system will refuse to enter another dose that the patient has taken, this involves careful consideration of patient safety, system security, and regulatory compliance, particularly in healthcare environment.



Vaccinated Children Report

Names	Reg_No	Start Date	Gender	Period	Vaccine Type	Nuse names	health_center	Date
gwiza kirabo	9175600	2023-08-29	Female	2	RV* Rotavirus	Scovia S	Kicukiro	2023-10-03 18:36:56
karabo gagata	6708619	2023-10-17	Male	0	HepB Hepatitis B	Scovia S	Kicukiro	2023-10-17 17:13:20
keza mian	5290986	2023-10-02	Female	0	HepB Hepatitis B	Scovia S	Kicukiro	2023-10-03 18:50:08
keza mian	5290986	2023-10-02	Female	1	HepB Hepatitis B	Scovia S	Kicukiro	2023-10-03 18:50:55

Figure 21: ***Vaccinated Children Report***

Figure 21 shows total vaccinated children reports with all information needed for analysis and decision making about children whereby nurse can search the information of individual child by registration Number (Reg Number).

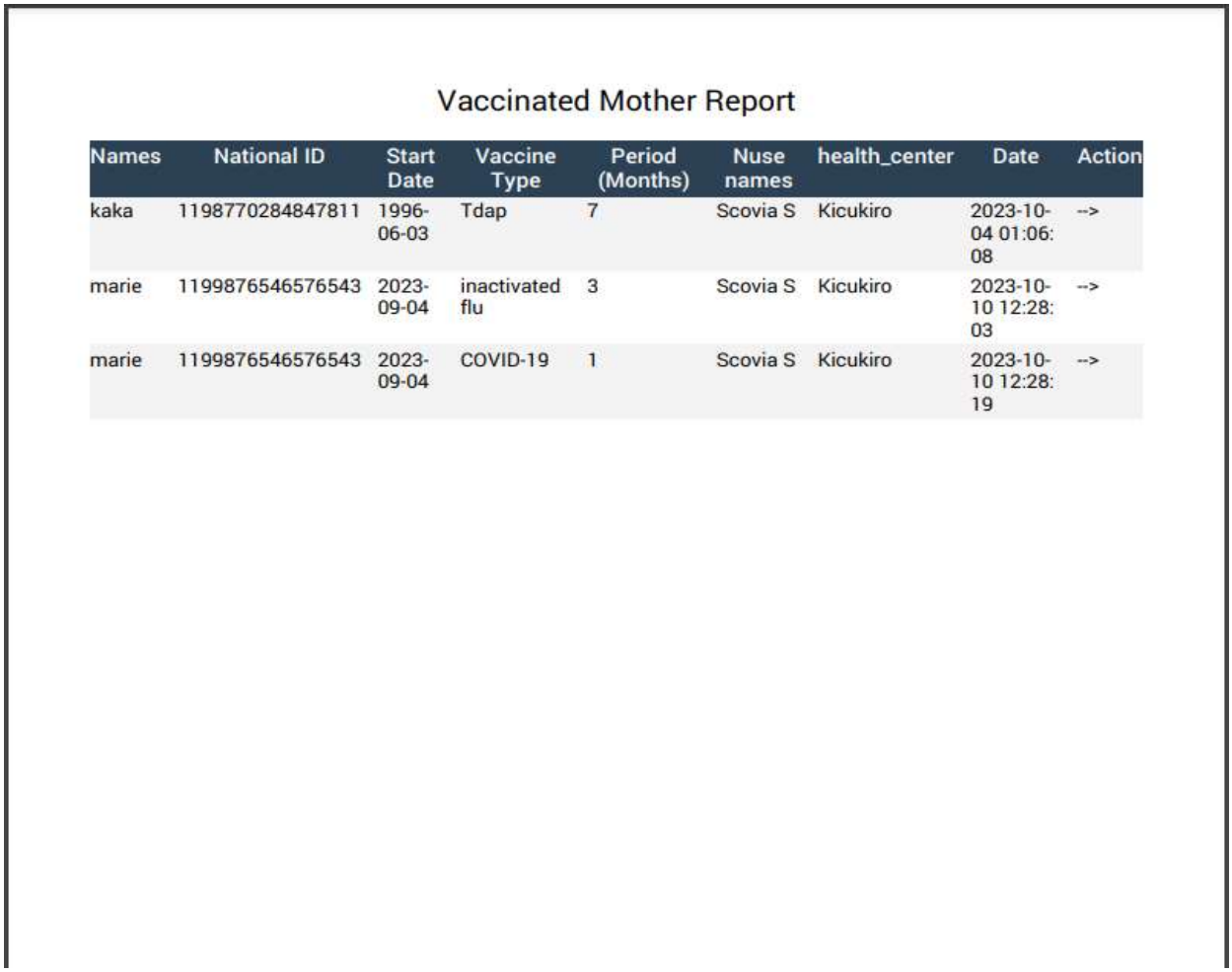


Figure 22: ***Vaccinated Pregnant Mothers Report***

Figure 22 shows total vaccinated pregnant mothers reports with all information needed for analysis and decision making about pregnant mothers whereby nurse can search the information of individual Pregnant mother by National Identification Number (National ID).

CHAPTER 5: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary

This research project was to design and develop a proper vaccination system to replace existing manual procedure to help vaccination department to get every vaccine to schedule on a date for pregnant mother and child in Rwanda using Vaccination Tracking Information System. Vaccination is the way of prevention from various infectious diseases. In many countries the process of Vaccination system is not technology based. In Rwanda patients (child and pregnant woman) use manual Vaccination system still now which is not secure.

The existing systems are the paper-based system therefore peoples are going to be digitalized on their particular life in Rwanda. each of both category of patients wants secured and flexible vaccination tracking Information system than the existing manual system, the management of all childhood and motherhood vaccination services relied on the use of vaccination cards to track vaccines received and set the appointments for future vaccination dates also on paper. This information was manually recorded for reporting purposes and program monitoring which is time consuming for both vaccination Department in RBC and Patients. Information system for Monitoring Vaccinations can solve many problems to monitor and maintain proper vaccination system especially problem of an unaware mother at third world country and child health about vaccination service.

Information System for Monitoring Vaccinations (ISMV) is web-based system, the methodology used includes primary and secondary data collection, interviews, questionnaires and documentation. In addition, several technologies were also used to develop the system, such as HTML, CSS, JavaScript as Front-end languages, PHP as Server-side languages, MySQL as Database and PhpMyAdmin, Apache as Database GUI tools.

Furthermore, the research design and implementation of the prototype of Vaccination Tracking Information System allow the system admin to register Nurses in order to gain credentials on the system for the treatment of children under five years and pregnant mothers in vaccination services. This research contributes to the development and implementation of VTIS which improves the management and the security of the patients which request vaccinations services at health center. During the production phase of ISMV, this system will be integrated with some telecommunication company in Rwanda like MTN Rwanda for sending appointment notification to the patient who request the vaccination service.

The system provides an effective way for administrators to view the dashboard, a graphical user interface therefore it has also an android component that allows users to integrate the system into their smartphones. System updates dynamically the time and dates based on when an individual vaccinated and given appointment. The specific objectives are to perform a basic analysis of the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department; to present an overview of a digital vaccination system; the system will be used to register and track individual immunization status and generate more accurate population estimates and vaccination targets in vaccination department; the system will help RBC Rwanda to identify and focus limited resources on high-risk populations; the doctors (nurses) will monitor vaccination coverage, vaccinator performance and vaccine stocks in easy way; Mostly parents lost their child vaccines schedule cards which is very important.

But web-based vaccines system reminds the parents about upcoming appointment with the automated notification system; Parents also get a facility to monitor vaccination activity by mobile application and parents may get relief from the discordance environment; No duplication of data entry and security system is strong; and Easy to make procedure reports and time maintain. The study verified the following null and alternative hypotheses which are Ha1: It possible to develop effective software that can help RBC Rwanda especially at Vaccination department to get the information on vaccination records of children under five years and pregnant mothers in order to improve vaccination services to those both categories and save time with improving quality of service offered by vaccination department; Ho1: It is not possible to develop effective software that can help RBC Rwanda especially at Vaccination department to get the information on vaccination records of children under five years and pregnant mothers in order to improve vaccination services to those both categories and save time with improving quality of service offered by vaccination department. The target population was 41 people from RBC in charge of vaccination distribution and tracking. The sample size of the study was all these 41 people taken as whole using census survey for gathering necessary information about vaccination tracking information. Data collection instruments were documentation study technique; interviews and questionnaires techniques.

5.2 Conclusion

The proposed system is user-friendly because the online based system provides more facility and

flexibility to the user means that through Vaccination department in RBC, all Healthcare (health centers) can uses this system in order to solve the mention problem in chapter one, some of them are if parent come without vaccination card, parents did not get a permit to vaccines their child. Even some parents tell the wrong date of the previous dose which causes threat for children.

Therefore, a user can access it without any cost or any stress. The main aim of this research is to develop the health technology by replacing the manual system with online base/Android apps in delivering the quality of service in health sector. A user can access this system using their smartphone by a mobile application. Usually, most of the parents forget their child vaccination schedule and also lost the vaccination card. This system helps nurses by sending notification SMS on their phone number which registered during the registration process for reminder or alert the next vaccine to take.

All of these problems can be eliminated by using the proposed system. It also shows that how can we manage and maintain proper child vaccination schedule from cloud and android application. The limitations of my system are that the development of an Android application for this research is a web view application, not the native one. It can create some problem in the older android device due to non-native functionalities. In future work, we will extend this feature. If RBC Rwanda accept my suggested system, then it could be helpful to all Healthcare countrywide and all parents who request the service of vaccination of their children and pregnant women.

5.3 Recommendations

Designing a Vaccination Tracking Information System for pregnant mothers and children under five years in Rwanda is a crucial step in improving healthcare and reducing preventable diseases. The recommendations for the Rwanda Biomedical Center (RBC) specifically Vaccinations Department, to ensure the successful implementation and utilization of this system.

For future researchers who will be interested in this system to include other modules that, I have not ventured into, like stock management of vaccinations, to alert the providers of Vaccinations when vaccines are decreased in stock.

By implementing these recommendations, RBC, Vaccination department will be benefit in effective manner and sustainable way about Information System for Monitoring Vaccinations that contributes to improved healthcare outcomes for pregnant mothers and children.

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APPENDICES

Appendix 1: Sample Codes

Codes for Vaccinated Children

```
<!DOCTYPE html>
<html lang="en">

<head>
    <meta charset="utf-8">
    <meta http-equiv="X-UA-Compatible" content="IE=edge">
    <meta name="viewport" content="width=device-width,
initial-scale=1">
    <title>Vaccination Tracking System</title>
    <!-- ================= Favicon ================== -->
    <!-- Standard -->
    <link rel="shortcut icon"
href="http://placehold.it/64.png/000/fff">
    <!-- Retina iPad Touch Icon-->
    <link rel="apple-touch-icon" sizes="144x144"
href="http://placehold.it/144.png/000/fff">
    <!-- Retina iPhone Touch Icon-->
    <link rel="apple-touch-icon" sizes="114x114"
href="http://placehold.it/114.png/000/fff">
    <!-- Standard iPad Touch Icon-->
    <link rel="apple-touch-icon" sizes="72x72"
href="http://placehold.it/72.png/000/fff">
    <!-- Standard iPhone Touch Icon-->
```

```
    <link rel="apple-touch-icon" sizes="57x57"
href="http://placehold.it/57.png/000/fff">
    <!-- Styles -->
    <link href="css/lib/select2/select2.min.css"
rel="stylesheet">
    <link href="css/lib/font-awesome.min.css"
rel="stylesheet">
    <link href="css/lib/themify-icons.css"
rel="stylesheet">
    <link href="css/lib/menubar/sidebar.css"
rel="stylesheet">
    <link href="css/lib/bootstrap.min.css"
rel="stylesheet">
    <link href="css/lib/helper.css" rel="stylesheet">
    <link href="css/style.css" rel="stylesheet">
</head>

<body>

<?php

include "dist/sidebar.php";
include "dist/header.php";
?>
        <!-- /# sidebar -->
```

```
    <div class="content-wrap">
        <div class="main">
            <div class="container-fluid">
                <div class="row">
                    <div class="col-lg-8 p-r-0 title-
margin-right">
                        <div class="page-header">
                            <div class="page-title">
                                <h1>Add Vaccinated
Child</h1>
                            </div>
                        </div>
                    </div>
                    <!-- /# column -->
                    <div class="col-lg-4 p-l-0 title-
margin-left">
                        <div class="page-header">
                            <div class="page-title">
                                <ol class="breadcrumb">
                                    <li class="breadcrumb-
item"><a href="#">Dashboard</a></li>
                                    <li class="breadcrumb-
item active">Vaccinated Child</li>
                                </ol>
                            </div>
                        </div>
                    </div>
                    <!-- /# column -->
```

```
                </div>
                <!-- /# row -->
                <section id="main-content">
                    <div class="row">
                        <div class="col-lg-12">
                            <div class="card">
                                <div class="card-body">
                                    <div class="form-
validation">

                                    <?php
                                    if(isset($_GET['error'])){
                                    ?>
                                    <div class="alert
alert-danger"><?=$_GET['error']?></div>
                                    <?php
                                    }
                                        ?>

                                        <form class="form-
valide" action="server.php" method="post">
                                            <div
class="form-group row">
                                                <label
class="col-lg-4 col-form-label" for="reg_no">Registration
number <span class="text-danger">*</span></label>
                                                <div
class="col-lg-8">
```

```
                                                    <input
type="text" class="form-control" id="reg_no" name="reg_no"
placeholder="Enter registration number " required>
                                                </div>
                                            </div>

                                            <div
class="form-group row">
                                                <label
class="col-lg-4 col-form-label" for="fname">Firstname
<span class="text-danger">*</span></label>
                                                <div
class="col-lg-8">
                                                    <i
nput type="text" class="form-control" id="fname"
name="fname" placeholder="Enter Firstname"
required  readonly>
                                                </div>
                                            </div>

                                            <div
class="form-group row">
                                                <label
class="col-lg-4 col-form-label" for="lname">Lastname <span
class="text-danger">*</span></label>
                                                <div
class="col-lg-8">
```

```
                                                                <i
nput type="text" class="form-control" id="lname"
name="lname" placeholder="Enter lname" required readonly>
                                                                    </div>
                                                                </div>

                                                            <div
class="form-group row">
                                                                <label
class="col-lg-4 col-form-label" for="val-username">Vaccine
Type <span class="text-danger">*</span></label>
                                                                <div
class="col-lg-8">
                                                                    <selec
t name="vaccine_type" class="form-control" required
id="vaccineSelect">
                                                                        <o
ption value="">-- Select here --</option>
                                                                    <?php
                                                                    $sql =
"SELECT * FROM vaccinations where category='Child'";
                                                                    $qry =
mysqli_query($conn, $sql);
                                                                    while
($rows = mysqli_fetch_array($qry)) {
                                                                        ec
ho '<option value="' . $rows['vaccineid'] . '">' .
$rows['vaccinetype'] . '</option>';
```

```
                                                    }
                                                    ?>
                                                </select>
                                                </div>
                                            </div>
                                            <div
class="form-group row">
                                                <label
class="col-lg-4 col-form-label" for="val-period">Period
<span class="text-danger">*</span></label>
                                                <div
class="col-lg-8">
                                                    <input
type="text" class="form-control" id="val-period"
name="period" placeholder="Enter Period. separete with
comma (,)" required readonly>
                                                </div>
                                            </div>

                                            <div
class="form-group row">
                                                <label
class="col-lg-4 col-form-label" for="val-purpose">Purpose
<span class="text-danger">*</span></label>
                                                <div
class="col-lg-8">
                                                    <input
type="text" class="form-control" id="val-purpose"
```

```
name="purpose" placeholder="Enter Purpose" required
readonly>
                                                    </div>
                                                </div>



                                                <div
class="form-group row">
                                                    <div
class="col-lg-8 ml-auto">
                                                        <butto
n type="submit" class="btn btn-primary"
name="child_vaccination">Submit</button>
                                                    </div>
                                                </div>
                                            </form>
                                        </div>
                                    </div>
                                </div>
                            </div>
                            <div class="row">
                                <div class="col-lg-12">
                                    <div class="footer">
                                        <p>2023 © Admin Board.
</p>
                                    </div>
                                </div>
```

```
                    </div>
                </section>
            </div>
        </div>
    </div>



    <!-- jquery vendor -->
    <script src="js/lib/jquery.min.js"></script>
    <script
src="js/lib/jquery.nanoscroller.min.js"></script>
    <!-- nano scroller -->
    <script src="js/lib/menubar/sidebar.js"></script>
    <script src="js/lib/preloader/pace.min.js"></script>
    <!-- sidebar -->

    <!-- bootstrap -->
    <!-- Select2 -->
    <script
src="js/lib/select2/select2.full.min.js"></script>
    <script src="js/lib/form-
validation/jquery.validate.min.js"></script>
    <script src="js/lib/form-validation/jquery.validate-
init.js"></script>
    <script src="js/lib/bootstrap.min.js"></script><script
src="js/scripts.js"></script>
    <!-- scripit init-->
```

```
    <script src="https://code.jquery.com/jquery-
3.6.0.min.js"></script>

<script>
$(document).ready(function() {
    $('#reg_no').on('input', function() {
        var reg_no = $(this).val();

        $.ajax({
            url: 'get_user_data.php', // Replace with the
actual PHP script
            method: 'POST',
            data: { reg_no: reg_no },
            success: function(response) {
                var data = JSON.parse(response);
                // $('#fname').val(data.fname);
                // $('#lname').val(data.lname);
                if (data.fname == null || data.fname ==
"") {
                    // Handle the error, show an error
message, clear fields, etc.
                    console.log("Error: Firstname is empty
or null");
                    if (reg_no.length >= 7){
                        $('#reg_no').val('');
                        $('#fname').val('');
                        $('#lname').val('');
                    }
```

```
                } else {
                    $('#fname').val(data.fname);
                    $('#lname').val(data.lname);
                }
            }
        });
    });
});
</script>
    <script>
$(document).ready(function() {
    // When a vaccine is selected
    $('#vaccineSelect').on('change', function() {
        var selectedVaccineId = $(this).val();

        // Send an AJAX request to fetch corresponding
data
        $.ajax({
            url: 'get_vaccine_data.php', // Replace with
the actual PHP script
            method: 'POST',
            data: { vaccine_id: selectedVaccineId },
            success: function(response) {
                // Parse the JSON response
                var data = JSON.parse(response);

                // Populate the readonly fields
                $('#val-period').val(data.period);
```

```
                $('#val-purpose').val(data.purpose);
            }
        });
    });
});
</script>

</body>

</html>
```

Appendix 2: Research Questionnaire

1. **What is your Gender?**

Females ☐

Males ☐

2. **How old are you?**

18-24 years ☐

25-34 years ☐

35-44 years ☐

45-54 years ☐

3. **Are you Nurse or doctor of a child under the age of five?**

Yes ☐

No ☐

4. ***How is the pregnant mother and child mortality cases due to the lack of vaccination information in vaccination department?***

	SA	A	N	D	SD
1) Pregnant women and children miss out on essential vaccinations due to a lack of information or access to vaccination services;					
2) Pregnant women do not receive proper prenatal care, including information about vaccinations leads to complications during pregnancy or childbirth;					
3) Lack of awareness about vaccination schedules and timely vaccinations result in missed opportunities;					
4) Some of the children under five still do not receive vaccinations which lead to risk of severe illnesses, hospitalizations, or even death;					
5) Low vaccination rates within a community lead to reduced herd immunity, making it easier for infectious diseases to spread;					

5. **Whether designed system can help RBC Rwanda to identify and focus limited resources on high-risk populations; reminded families and health providers when vaccinations were due or missed?**

	SA	A	N	D	SD
1) The designed system effectively can help RBC Rwanda to identify high-risk populations/pregnant mother and children under five years missed vaccines;					
2) The system consistently can remind families and health providers when vaccinations are due or have been missed;					
3) The system can facilitate doctors and nurses in monitoring vaccination coverage in an easy and efficient manner;					
4) The system can allow for easy monitoring of vaccinator performance in delivering vaccines;					
5) The system can help in maintaining adequate vaccine stocks, ensuring a steady supply for immunization programs;					

Appendix 3: Duration of project

Task Name	January	February	March	April	May	June	July	August	September
Proposal Outlining									
Making appointment									
Organization and analysis of data									
Compiling data									
Implementing the project									
Testing the project									
Preparation for presentation									
Defense of the Research									

Table 7*:Duration of the project and Activity plan 2023*

END