MOBILE APPLICATION FOR DIABETES MONITORING AND MANAGEMENT

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CERTIFICATION

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DEDICATION

This Project is dedicated to God Almighty

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ABSTRACT

Health is a multi-dimensional build with various viewpoints just as different determinants. Among elements that could impact the health result is the sufficiency of health administrations which in numerous settings are intended to be accessible, moderate, open, and proper just as being fairly conveyed. Also Prevalent is the poor health care system being delivered in most health care centers, particularly in the aspect of monitoring and managing diabetic patients in Nigeria, the main focus of this work is to design a cross platform mobile application for proper diabetic management and monitoring in Nigeria. And its main objective is to design a mobile based application for diabetes management and compare the designed application with existing ones.

A mobile application called Diacare for diabetes management was developed using Ionic framework.

Ionic Creator was used in building a user interface by dragging and dropping ready-made components. It was implemented in designing the final appearance of the application. The ionic view makes it very easy for users to run and share developed apps to multiple devices using simple command and before they are transferred to the official market store Ionic Market was used in sharing the mobile applications, charging a fee to download it. In addition, it has credible user support along with documentation for useful information. Ionic lab for testing newly developed application on and android and IOS Ionic resource provides a documentation to showcase how easily one can learn and grasp it use on mobile platforms.

It was concluded that even with the current rapid development and increased use of modern technologies, mobile applications for diabetes shows that existing solutions do not provide a comprehensive service about maximum adherence hence self-monitoring is a requirement for the proper education of people with diabetes. Better education increases adherence, i.e., the extent to which patient behavior (drug use, compliance with regimens) coincides with medical advice or medical standards.

Keywords: **Mobile application, Diabetes, cross-platform, Monitoring and management.**

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

There is not yet an agreement on the meaning of nature of consideration however there is an assembly of perspectives that the meaning of nature of consideration ought to incorporate consideration characteristics, for example, treatment adequacy, effectiveness, the propriety of wellbeing mediations just as value.

Health is a multi-dimensional build with various viewpoints just as different determinants. Among elements that could impact the health result is the sufficiency of health administrations which in numerous settings are intended to be accessible, moderate, open, and proper just as being fairly conveyed. (Benson, Adetutu, Roland and Daprim, 2018). These administrations could be conveyed from multi-level framework and from secretly or freely owned health centers. For either open or private health offices, there keeps on being the worry of whether health administrations are conveyed such that ensures ideal customers and other partners' fulfillment with administrations gave.

Health administrations are considered as very relevant amongst the most vital needs in human life. To give increasingly qualified administrations to their patients' wellbeing, administrations utilize the inventive versatile patient checking framework (MPMS) answers for improve human services frameworks and to give better administration. Nowadays advancement expect a fundamental occupation to improve prosperity organizations. Right now the use of portable applications in any zone and want of individuals who need to be online each time influence and change the improvement of telemedicine advancements in wellbeing division as like in all areas. In telemedicine, advances and different zones million applications are creating in these days and are served to clients. These applications have numerous properties other than convey answers for issues that the clients looked in day by day life. Along the expansion in versatile applications make simpler patient following and increment sparing in establishments. With the versatile patient following framework in this setting it's provided that no convincing motive to go to medical clinic for fundamental estimations and nonstop checking and furthermore putting away the estimations in a focal putting away framework. Additionally, it's pointed that quicken the treating to grim

persistence by isolating the typical and grim assessments. In encapsulation right off the bat the information taken from the warmth, temperature, diabetes and heart cadence sensors sent to the Arduino small scale controller framework at that point sent to the mobile phone which has Android working framework and upheld NFC or Bluetooth and in conclusion sent to the focal putting away framework by this cell phone. (Bulent Cobanoglu, I.F. Oguzhan Atmaca, 2018).

The nature of medicinal services administrations has been improved with the development of innovation. Quiet checking frameworks consistent mechanical advancements in human services have spared countless lives and improved the personal satisfaction for considerably more. Not just has innovation changed encounters for patients and their families, it has additionally hugely affected restorative procedures and the acts of social insurance experts. One of the leaps forward of innovation in social insurance is the patient medicinal services observing and the executive's framework (Benson et al., 2018).

Monitoring and management of health services can be defined as the delivery of health services in a way that adapts to the pre-conceived requirements and prospects of patients and their family members. When pre-conceived prospects are met by the health care provider, the patients and family members see the services as acceptable. The reverse is the case if these expectations are not met and a patient or the family members term the health services as unacceptable. Such negative experiences directly affect future utilization of the health services. Other factors known to affect the monitoring and management of health services include lack of trust and respect between the care provider and the patient (user of health service), poor inter-cultural relations (World Health Organization Journal, 2018). Hence, the focus of this work is to design and implement a mobile application for the monitoring and management of diabetes.

1.2 STATEMENT OF THE PROBLEM

Diabetes has become very common and is increasing in an uncontrolled way worldwide as ascertained by the World Health Organization who verified based on recent survey that the disease was the seventh driving reason for death in 2016 worldwide (World Health Organization, 2018).

Also prevalent is the poor health care system being delivered in most health care centers, particularly in the aspect of monitoring and managing diabetic patients in Nigeria. Hence, the main

focus of this work is to design a cross platform mobile application for proper diabetic management and monitoring in Nigeria.

1.3 AIM AND OBJECTIVE OF THE STUDY

The aim of this study is to design a health monitoring and management mobile application for diabetic patients.

The specific objectives of this study are to:

1. Design a mobile based application for diabetes management.
2. Compare the designed application with existing ones.

1.4 SCOPE OF THE STUDY

This study focuses on the design and implementation of a cross platform mobile application named Diacare for the monitoring and management of diabetic patients in Nigeria.

1.5 SIGNIFICANCE OF THE STUDY

Practically, this study will help developers and also medical communities by providing theoretical foundations that can help in the design and implementation of diabetes monitoring and management mobile applications.

This work will also make significant contributions in Nigeria's health sector by making people understand and become more aware about the importance of using numerous health applications online.

1.6 METHODOLOGY

In other to achieve the first objective, a cross-platform application for diabetes management called Diacare will be designed using Ionic Cordova platform, Windows Operating System, MySQL database, Apache Server, Node.js, PHP, Bootstrap, Phone Gap, Apache ANT and jQuery.

To achieve the second objective, the developed app will be compared with two other popular diabetes monitoring and management health care apps in the google play store.

1.7 DEFINITION OF TERMS

Application: An application is any material, product or a program which is designed for end-user to use

Diabetes: A disease in which the body's ability to produce or respond to the hormone insulin, is impaired or damaged, resulting to abnormal metabolism of carbohydrates and elevated levels of glucose in the blood.

Framework: A framework is a concept of how a software providing generic functionality can be selectively modified by additional user-written code, therefore providing application-specific software.

Mobile: Mobile or mobile device is any portable device (gadget) that can make and receive calls over a radio frequency link while the user is moving within a telephone service area.

Monitoring: Monitoring is the Monitoring is an organized method used for the collection, analyzing and usage of information to track a program's progress toward reaching its objectives and to guide management decisions.

Management: Management is the planning, organizing, directing, conducting and supervising of any system.

Insulin: Insulin is a hormone produced in the pancreas by the Islets of Langerhans, that helps to regulate the amount of glucose in the blood.

Mhealth: (mobile health) is a general term for the use of mobile phones and other wireless technology in medical care.

1.8 ORGANISATION OF WORK

In this work, Chapter One discusses the Introduction of the topic, Chapter two talks about literature review and review on related works, Chapter three discusses on the methods used in achieving the said objectives laid down in Chapter One, with the Software Development Life Cycle that is been employed in the implementation of the proposed design. Chapter four talks about the

implementation of the proposed system, Chapter Five discusses the summary, conclusion and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUTION

This chapter discussed some frameworks currently used in diabetes management with their limitations, conceptual and theoretical review of the disease and its prevalence especially in Nigeria. The chapter also reviewed some related works that have been done and gaps identified.

2.1 CONCEPTUAL REVIEW

Health service delivery systems that are safe, accessible, high quality, people-centered, and integrated are critical for moving towards universal health coverage. Health service delivery systems are put in charge for the provision of health services for patients, families, communities and the whole population and not only care for patients. Whereas patient-centered care is commonly understood as concentrating on the person seeking care (the patient), patient-centered care includes these clinical encounters and also includes kin attention to the health of people in their vital role in shaping health policy and services.

The need for improved health care service quality and increased efficiency in health care service driven by the incorporation of both product and process innovations into the health care delivery system is because awareness of the concept of quality of health services is on the increase in recent years on the part of the public and consequently on the Government, providers of health care and other emerging stakeholders which in turn has improved health care service quality.

There is an apparent need for concerted efforts to be made in the improvement of the quality of health care delivered to the Nigerian populace. The pace of development of quality health care services in Nigeria remains quite unsatisfactory, despite the investments into primary, secondary and tertiary health care, coverage for basic health care services is especially for the rural populace of the country is yet to be attained. These provides stronger imperative to validate and fast-track monitoring and management of national health plans and on-going health reforms.

The number of individuals with diabetes has increased from 108 million out of 1980 to 422 million of every 2014. The worldwide predominance of diabetes among grown-ups more than 18 years old has increased from 4.7% in 1980 to 8.5% in 2014. Diabetes commonness has been rising all

the more quickly in center and low-pay nations. Diabetes is a noteworthy reason for visual deficiency, kidney failure, heart attacks, stroke and lower appendage removal. In 2016, an expected 1.6 million deaths were legitimately brought about by diabetes. Another 2.2 million deaths were inferable from high blood glucose in 2012. Practically 50% of all deaths inferable from high blood glucose happen before the age of 70 years. WHO evaluates that diabetes was the seventh driving reason for death in 2016 worldwide (World Health Organization, 2018)

2.1.1 CROSS PLATFORM MOBILE APP FRAMEWOK

There are numerous frameworks for developing cross platform mobile applications such as Ionic, Xamarin, Appcelerator Titanium, Kendo UI, Phone Gap, Sencha touch amongst others. Highlighted are brief discussion on selected few.

Ionic: Ionic is developed with Cordova, it implies, it contains the Cordova file structure to package HTML/CSS/JavaScript into applications that can keep running on both versatile and work area gadgets. It additionally gives a plugin engineering that is utilized in getting to Native features beyond what JavaScript can accomplish on a web browser. Ionic uses the CSS broad property called Syntactically Awesome Style Sheets (SASS), which is used optionally by developers to state a value once and used in more than one place within the same style sheet document.

Mobile Angular user interface: This is described as a composition of crucial parts such as JavaScript, AngularJS directives, click.JS, overthrow.JS and Bootstrap3 to provide functions such as sidebars, scroll bars, switches, overlays, sidebars, absolute positioning for top and bottom numbers. These parts work together to achieve interactive mobile user interface (UI) and also responds to media queries for mobile applications.

Xamarin: This is a hybrid mobile application development framework, that finds solution to the problem programmers are faced with when developing a cross-platform mobile application: separate coding languages and UI paradigms. Xamarin aids developers to use C# for building IOS and android and Windows applications. It works adequately with appropriate and basic process of creating forms, interface design using its XAML-based framework. Xamarin was founded in May, (2011) by Microsoft-owned San Francisco, California-based programming organization established which has cross-stage executions of the Common Language Infrastructure (CLI) and Common Language Specifications (regularly called Microsoft .NET). Developers can utilize

Xamarin instruments to write native and android, iOS and Windows application with native UIs and share code over numerous platforms.

Appcelerator Titanium: This is a cross-platform mobile development tool that use open source standards. It exposes the developers to build applications that will run on tablet, PCs, smart phones and desktops. Titanium Mobile SDK comes with its own IDE. Titanium Studio is similar to Eclipse IDE used in writing and test applications with the aid of the Emulator. Appcelerator works with database, media, geo-location, contacts, notification and many other native features of a smartphone. Titanium aids web developers to create native mobile, desktop, and tablet applications using open web technologies such as JavaScript, HTML and CSS. Streaming an audio clip can use from 50-500 lines of code of Objective-C or Java, in Appcelerator Titanium a developer can simply write one line of JavaScript to point to a URL location to start clip streaming (Dinka, Emmanuel & Oyeyinka, 2017).

Intel XDK: This is a cross-platform application tool built by Intel Company. It makes use of drag and drop method for development, which includes web services and plugins for content rich, interactive applications, responsive applications run on any device. Intel SDK supports development, emulation, testing, debugging publishing. In recent times, they made some major changes by supporting all the capabilities such as developing mobile HTML5 and Apache Cordova for android, iOS, Windows 10 UAP, including software development capabilities for Node.JS-based, on-board, Internet of Things (IoT) apps too. Intel XDK allows development via a drag and drop approach and also live preview on the connected device while development is going on.

2.2 THEORETICAL REVIEW OF DIABETES

2.2.1 Origin of Diabetes

Diabetes mellitus is one of medical disorders that have been comprehensively studied. Regardless of these vast developments the cure for diabetes still remains under research. The history is backdated to the Egyptian antiquity. As the history became unraveled with regard to the pathophysiological and biochemical bases, medical and surgical treatments and other management strategies, roadmap towards achieving success in shortening the risk of diabetes is promising. It is only in the 21st century that diabetes has been measured as a chronic and diverse endocrine sickness which requires interdisciplinary and multidisciplinary methods in its management, with the role of genetics looking exciting. However, there are lots of lessons to be learnt from the past.

This research aims to explore the timeline of diabetes journey, and correct the irregularities in the historical angles of diabetes with intent to project the future.

Diabetes mellitus (DM) is described as a ‘silent’ epidemic. Its management can either be a slow onset and asymptomatic progression leading to ancillary complications, or fast developing side effects prompting entanglements or potentially extreme lethargies. The projection is that by year 2030, an expected 366-438 million (i.e., 7.8% of the total populace) individuals will have diabetes, an expansion of 54% contrasted with that anticipated in 2010 (Wild et al. 2004; Whiting et al. 2011). After the affirmation of diabetes by the Egyptians, a few endeavors were made to comprehend the assorted idea of the ailment, pathophysiological systems, fitting treatments and avoidance procedures. As a major aspect of looking for answers to charming inquiries in diabetes, a few creators were increasingly enlightening, diagnostic or cynical as opposed to logical in their inquiry. Progressive milestones in diabetes reflect enhancements in the understanding, monitoring and management of the condition. The overview of the history of diabetes, starting from the ancient time to the present millennium helps to showcase the advances that have been made in diabetes and health.

An attempt is made in this study to produce a chronologically organized, interesting and multi-dimensional account of diverse documented work in diabetes. An in-depth review of the historical timeline of diabetes shows that diabetes has evolved over six eras: era of recognition of disease, description of causes, clinical diagnosis, biochemical development and advancement and millennium developments.

This origin overview will help establish a comprehensive concept on diabetes.

2.2.2 Types of Diabetes

Type 1 Diabetes

This type of diabetes is also called insulin-dependent diabetes. It used to be called juvenile-onset diabetes, since it frequently starts in adolescence. Type 1 diabetes is an autoimmune system disorder. It's brought about by the body attacking its own pancreas with antibodies. The damaged pancreas does not make insulin in individuals with Type 1 diabetes. This kind of diabetes might be brought about by a hereditary inclination. This could be because of defective beta cells in the pancreas which regularly delivers insulin. Various medical risk is related with type 1 diabetes. A significant number of them

shoots from damage to the modest veins in the eyes (called diabetic retinopathy), nerves (diabetic neuropathy), and kidneys (diabetic nephropathy). Other extreme variables are expanded hazard in coronary illness and stroke. The treatment for Type 1 diabetes embroils taking insulin, which has to be injected through the skin into the fatty tissue. The methods of injecting insulin include:

- Syringes
- Insulin pens that use pre-filled cartridges and a fine needle
- Jet injectors that use high pressure air to send a spray of insulin through the skin
- Insulin pumps that dispense insulin through flexible tubing to a catheter under the skin of the abdomen

A test taken periodically called A1C blood test evaluates the glucose levels in the blood over three months. It is used to help ascertain the total glucose level control and risk of complications from diabetes, including damage in organ. Individuals with Type 1 diabetes are required to have significant change in lifestyle which includes:

- Regular testing of your blood sugar levels
- Careful meal planning
- Regular exercise
- Taking insulin and other medications when needed

People with Type 1 diabetes can live very long, active lives if they carefully monitor their glucose levels and make the needed lifestyle changes adhering also to the appropriate treatment plan.

Type 2 Diabetes

Type 2 diabetes is the most common type of diabetes, which accounts for 95% of diabetes cases in the older population. Type 2 diabetes was known as adult-onset diabetes but with the wide-range of obese and overweight people, more adults are now increasing with Type 2 diabetes. Apart from being known as adult-onset diabetes Type 2 diabetes was also called non-insulin-dependent diabetes. It is usually a milder form of diabetes compared to Type 1. Notwithstanding, Type 2 diabetes can still cause major health complications, particularly in the smallest blood vessels in the body that sustains the kidneys, nerves, and eyes. Type 2 diabetes increase the risk of heart disease and stroke; the pancreas usually produces some insulin but either the amount of the insulin isn’t enough for the body’s need or the body

cells are resilient to it. Primarily, in fat, liver and muscle cells insulin lacks sensitivity and resistance. High risk of developing Type 2 diabetes are particular in people who are obese – more than 20% over their ideal body weight for their height and its related medical challenges. Overweight people are resistant to insulin, resistance to insulin indicates that the pancreas have to work twice as hard to produce insulin. But nonetheless, sugar cannot be normal due to inadequate insulin. There is no cure for diabetes, regardless, Type 2 diabetes can be controlled with weight management, nutrition, and regular exercise. Unfortunately, Type 2 diabetes tends to keep growing and diabetes medications are often needed. A1C test evaluates average glucose levels in the blood over the previous three months. A1C test will be advised to be carried out periodically in order to see how well diet, exercise and medications are working to control blood sugar and prevent damage in organ, it is done a few times yearly.

Gestational Diabetes

Pregnancy triggers this type of diabetes which is known as gestational diabetes (pregnancy to some extent, brings about resistance in insulin). Frequently, it is diagnosed in the middle or towards delivery, because high blood sugar level in a mother is circulated through the placenta to the baby. Control monitoring and management of gestational diabetes should be done to ensure the proper growth and development of the baby.

According to the National Institutes of Health, the reported rate of gestational diabetes is between 2% to 10% of pregnancies. Gestational diabetes usually resolves itself after pregnancy. Mothers are at risk of developing Type 2 diabetes later in their life, because of gestational diabetes. 10% of women with gestational diabetes develop Type 2 diabetes, which can occur from a few weeks after delivery to years later.

Risks to the unborn baby are greater than risks to the mother with gestational diabetes, the baby is at risk to abnormal weight gain before birth, breathing problems at birth, and higher obesity and diabetes risk later in life while risk to the mother includes a cesarean section after delivery due to overly large baby, as well as damage to heart, kidney, nerves, and eye. Treatment during pregnancy includes working closely with your health care team and:

- Careful meal planning to ensure adequate pregnancy nutrients without excess fat and calories
- Daily exercise

- Controlling pregnancy weight gain
- Taking diabetes insulin to control blood sugar levels if needed

Other Forms of Diabetes

A few rare kinds of diabetes can result from specific conditions. For example, diseases of the pancreas, certain surgeries and medications, or infections can cause diabetes. These types of diabetes account for only 1% to 5% of all cases of diabetes.

2.2.3 Causes/Symptoms of Diabetes

According to (World Health Organization, 2017), below are some of the leading causes of diabetes globally

Frequent Urination

- Disproportionate thirst
- Intense hunger
- Weight gain
- Unusual weight loss
- Increased fatigue
- Irritability
- Blurred vision
- Itchy skin
- Numbness or tingling especially in your feet
- Sexual dysfunction especially among adult male.
- Frequent gum disease/infection

2.3 Prevalence of Diabetes

The prevalence of diabetes mellitus (DM) is increasing worldwide, and it is estimated that by the year 2030 over 500 million adults will be affected by Diabetes Mellitus. The increase could be as a result of growth, development and aging of the population. The projected increase in prevalence is expected to be higher in Africa and Asia where there is rapid epidemiological transition. The prevalence of Diabetes Mellitus is still lower in traditional rural than urban communities. Previous studies found the prevalence of 1.6% in a suburban Northern Nigerian city (Erasmus, 2012*) and*

found a prevalence of 1.4% in a rural population of North Central Nigeria (1.4%). Most cases of Diabetes Mellitus in rural and suburban areas remain undiagnosed, and many patients present for the first time with complications. The aim of our study was to determine the prevalence of Diabetes Mellitus and its correlates in a suburban population of Northwest Nigeria. (official publication of the Usman Danfodiyo Teaching Hospital, 2017)

2.4 Existing Applications for the Monitoring and Management of Diabetes

The use of mobile application in diabetes management has proven to modestly improve glycemic control. Fortunately, most patients today have access to mobile applications that can help them manage their diabetes and still keep their sugar level under control. There exist numerous applications for diabetes control and management such as Diabetes tracker, My sugr, BG monitor amongst others (Healthcare Mobile App Development and mHealth Apps, 2017). Highlighted are discussion of a few from the more popular ones.

i. **FOODUCATE**: This application educates users on nutrition and helps to eliminate unhealthy foods. Once you scan nutrition labels, you'll see ingredients as well as the health grade assigned to different foods. You can also log and track your food intake as well as your sleep, exercise, and mood. It was founded in 2008 by Hemi Weringar.

ii. **GLOOKO:** Managing diabetes involves knowing your numbers. Glooko monitors your medications, carb intake, and more. It integrates data from most continuous glucose monitors, blood glucose meters, insulin pumps, and fitness trackers. View your progress via charts and keep track of your history. If your doctor sponsors you, or your employer or insurer covers the fee, the app can be used completely free of charge. Glooko was founded in 2011 by Yogen Dalal.

iii. **HEALTH2SYNC:** Document your sugar readings, weight, and other factors that affect diabetes. View vital stats about your health including current and past trends. Released in Ed Deng in 2013, This app also lets you invite friends or family members for added support and motivation and allows you to sync with Bluetooth health devices.

iv. **GLUCOSIO:** Glucosio is an app for people with type 1 and type 2 diabetes. It monitors important metrics such as weight, hemoglobin A1c, ketones, cholesterol, blood pressure, and more. Glucosio was founded in 2015 by a group of open source developers. The app also includes glucose target tools and an HbA1c conversion calculator. Set reminders to

keep you in tune with taking medication, working out, and other important tasks. You can share data from the app anonymously if you choose.

v. **MYNET DAIRY CALORIE COUNTER:** Founded in 2005 but was launched in 2007. This app does all the work for you to evaluate your food diary and guide your weight management plan. Easily enter foods into the app by scanning barcodes. Get access to a large food database which can assign grades to food so you can get a quick view of how healthy or unhealthy certain choices can be.

2.5 Related Works

Many mobile applications have been designed to help monitor and manage diabetes. This has brought about ways that different researchers have proposed different methods to improve the monitoring and management of diabetes. This review consists of previous methods found by different researchers as summarized in Table 2.1.

Table 2.1 Summary of Literature Review

S/N	AUTHOR(S)	TITLE OF PAPER	PROBLEM STATEMENT	METHOD USED	CONTRIBUTION	LIMITATION
1.	Deborah A. Greenwood, Perry M. Gee, Kathy J. Fatkin. Et al (2017)	Evaluating Technology-Enabled Diabetes Self-Management Education and Support**.**	Ways by which currently available technology is impacting the outcome for people living with diabetes.	Reviewing current papers on it and comparing statistics.	Majority evaluated the use of mobile phones and secure messaging and concluded on four key elements. I. Communication, II. Patient-generated health data, III. Education, and IV. Feedback.	The review did not include studies of diabetes devices including insulin pumps and continuous glucose monitors due to the lack of mobile integration into practice.

2.	Dr. Omar El-Gayar, Prem Timsina, Nevine Nawar Et al(2013)	Mobile Applications for Diabetes Self-Management: Status and Potential.	To determine in a systematic way whether applications have been helping diabetic patients and to identify issues necessary for large-scale adoption of such interventions.	The review covers commercial applications available on the Apple App Store.	The application of sociotechnical design principles can significantly improve the adoption and wide-scale use of such technology	Lack of personalized feedback; usability issues, particularly the ease of data entry; and integration with patients and electronic health records.

3.	Gunther Eysenbach, Mary Adu, Ulrika Öberg, Geronimo Jimenez, Elaine Lum, and Josip Car,(2013)	Examining Diabetes Management Apps Recommended from a Google Search.	To investigate apps identified through a Google search and characterize these apps in terms of features that support diabetes management.	Information about each app was extracted from the papers and corresponding app store descriptions. And certain features were examined.	The lessons highlighted in this study could be extrapolated to other chronic diseases to inform the development and recommendation of safe and reliable apps.	Google searches vary depending on the country location in which they were performed, therefore, this same search performed elsewhere may result in different retrieved websites.

2.6 Research Gap

From works reviewed, it is seen that there exist many applications to monitor and manage diabetes but none has all the required content and standard Graphical User Interface (GUI), amongst others, this work tries to have quality content and standard Graphical User Interface (GUI) to overcome some of these limitations.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

The design of a mobile application for monitoring and managing of diabetes is to monitor and ensure proper health condition in diabetic patients. With improved changes of information and technology, the process by which patients and health practitioners monitor health conditions is changing drastically. The use of ICT in hospitals and health centres has led to the increase in the quality of health services. Coupled with the rapid changes of the ICT evolution in the society, the health sector should be along with the changes of modern society, too. With the use of Information Technology (I.T), health centres have benefitted.

3.1 Flowchart of mobile application

The flowchart depicts flow of control in program modules. The flowchart does not mention anything about how data flows through the system.

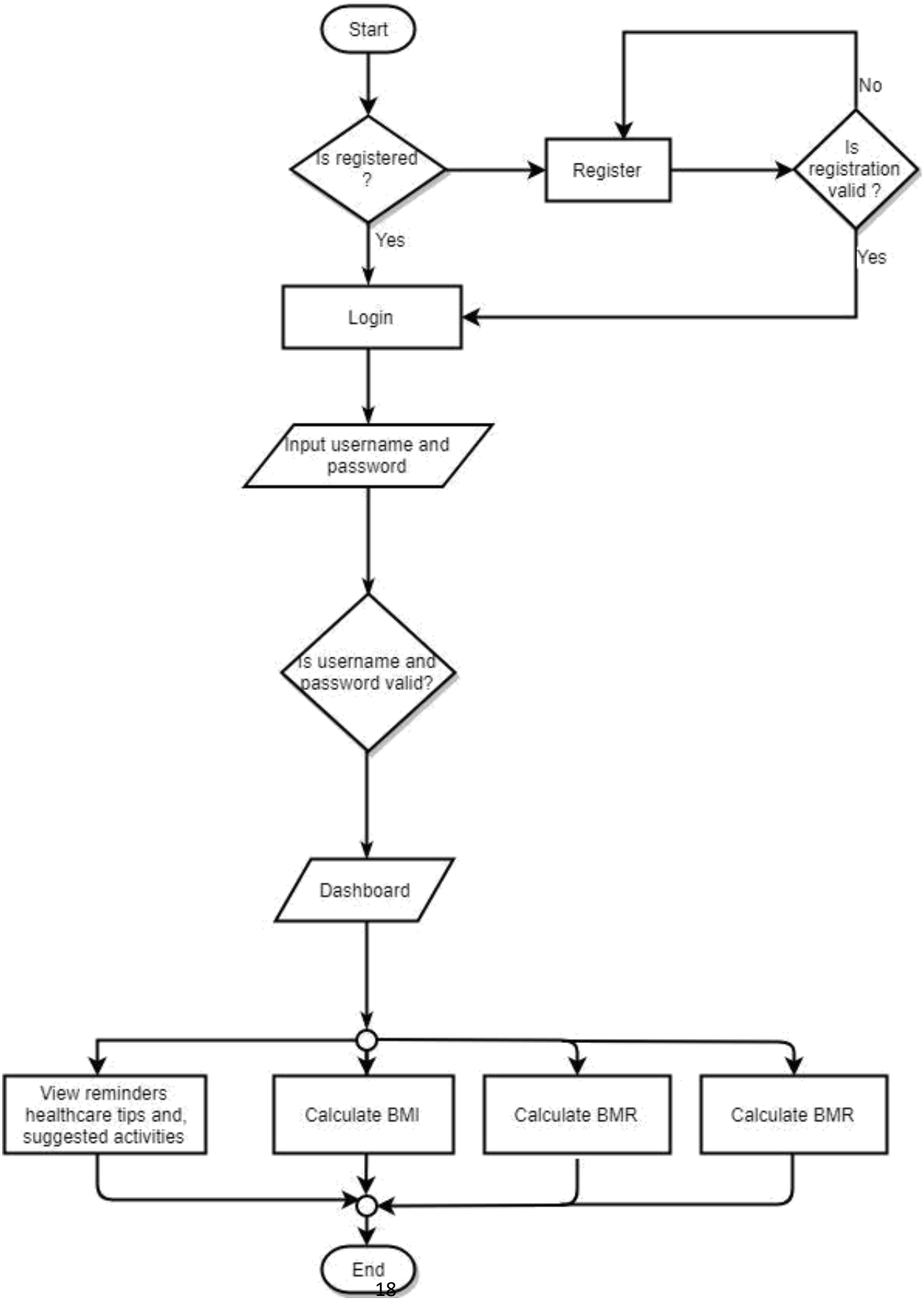

Start
Is registered ?
Register
Is registration valid ?
No
Yes
Yes
Login
Input username and password
Is username and password valid?
Dashboard
View reminders healthcare tips and, suggested activities
Calculate BMI
Calculate BMR
Calculate BMR
End

Fig 3.1: Flowchart of the Mobile Application

3.1.1 Authentication

The authentication of users on the mobile application is performed in three ways

I.) E-mail

II.) Password

E-mail The user enters his/her e-mail address.

Password: The user enters a password that is at least N characters long, that has at least one or more numeric and uppercase characters mixed with it and so on to gain access to the e-learning Management System after they have been registered to the system.

3.2 Use Case Diagram for User

The patient should be able to download and install the app on their mobile devices, register on the app, check their profile, patients should also be able to check glucose, weight, calories burned per min, per week, check their diet plan. Also as some plus feature, patients should be able to check progress report and update on the app, and health goals.

Use Case Diagram for User

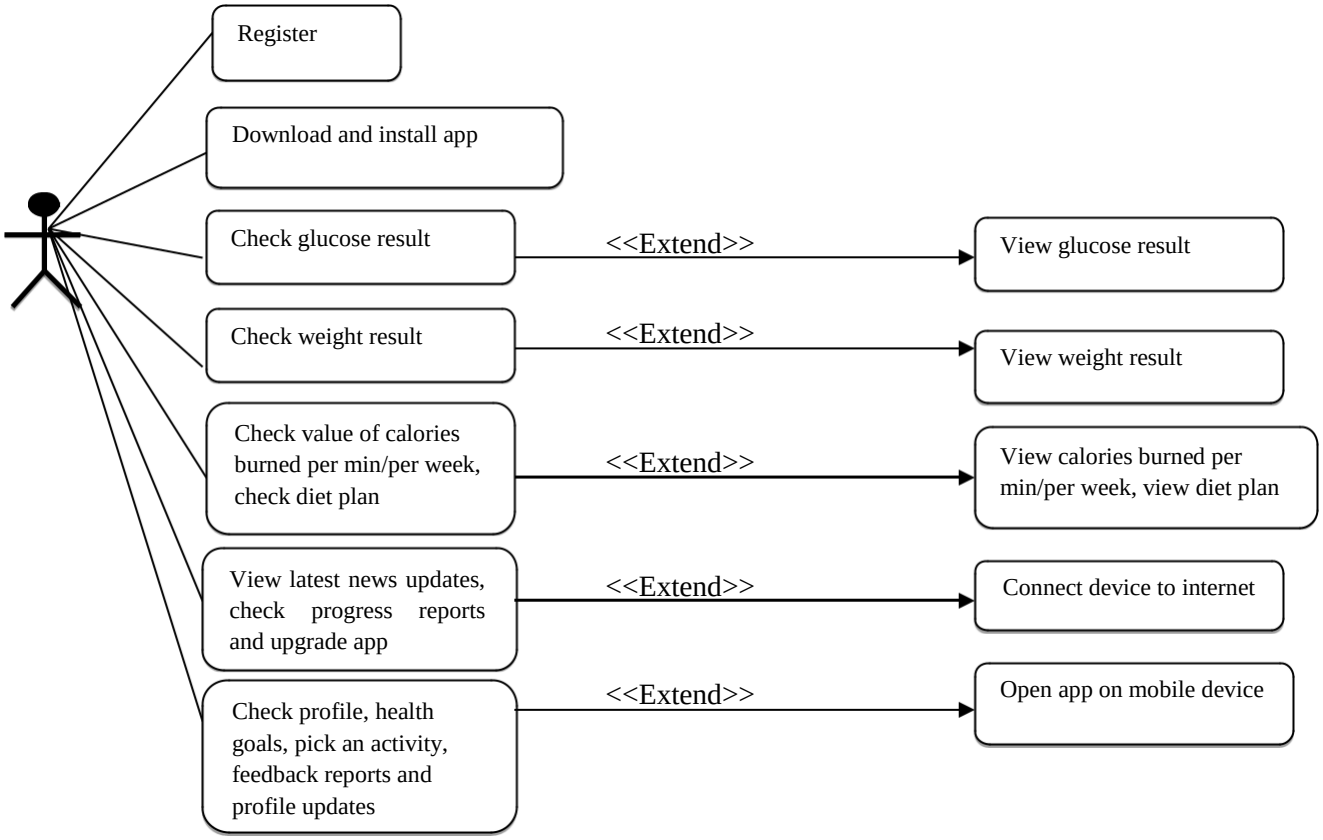


Figure 3.2: Use case diagram for User

3.3 Use Case Diagram for Administrator

The administrator should be able to login to the system, allow the app to be upgraded, send diabetes health tips and user's progress and also send latest upgrades and reminders.

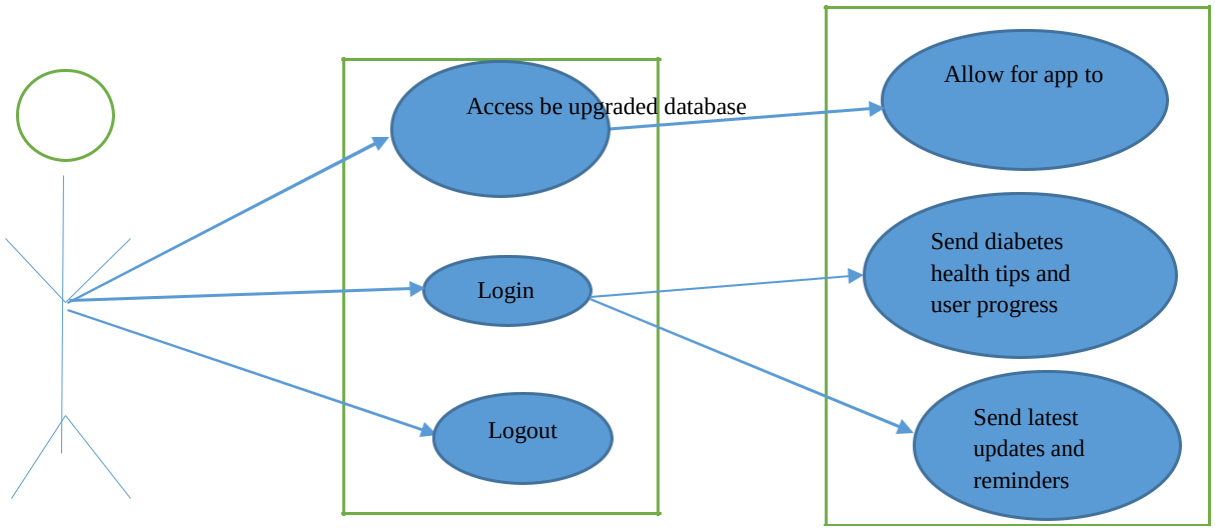


Figure 3.3: Use case diagram for Administrator

3.4 Software Development Lifecycle

Iterative waterfall model is being adopted for the implementation of the system. Here, we provide feedback paths for error correction at each phase and when detected later in a phase. However, it is desirable to detect errors which are inevitable in the same phase in which they occur. If so, this can reduce the effort to correct the bug. The advantage of this model is that at a very early stage of development there is a working model of the system, which makes finding functional or design flaws easier. The early development of problems enables corrective measures to be taken in a limited budget.

3.5 System Model

The system model was designed to show an abstract representation of how the developed system will look like after implementation. It showed the graphical representation of the functionality of the system which plays a vital role in software development. The system was modelled using the use case diagram.

3.6 Ethical Consideration

This research was carried out in accordance with Mountain Top University Research Ethics Committee rules and guidelines.

3.7 Expected Results

At the end of this study, it is expected that a mobile application for the management and monitoring of diabetes among the aged would have been designed. The work also would give an approach for developing cross platform applications in order to target a wider range of platforms and audience without having to write numerous versions of codes, for cost control, quicker development time based on technologies that will be used, easier implementation and uniformity.

CHAPTER FOUR

IMPLEMENTATION AND DOCUMENTATION

4.0 Introduction

This demonstrates the information of implementing a mobile application for diabetes monitoring and management. Designing and implementing a mobile application for diabetes monitoring and management considers some aspect, and while these components attempt to provide alternatives to the issues recognized and indicated in health services. It describes the tools used in developing and implementing the mobile application. These tools assisted in system design and development of the apps primary idea and functionality to accomplish its defined mission.

It also offers explicit description of how the proposed framework was designed and the underlying functionalities that define its makeup.

4.1 Diacare Architecture Design and Tools

A mobile application called Diacare for diabetes management was developed using Ionic framework. The framework was adopted based on its simplicity, popularity and maturity as also confirmed by Dinka, Emmanuel and Oyeyinka (2017). Ionic provides the ability for developers to develop the front-end User Interface (UI) that caters for the general representation, interactions, animations, looks, feel and beauty of the application. This framework has a low learning curve compared to others and the ability to write once and run anywhere (Huynh &Ghimire, 2017). Ionic is more of an ecosystem than a framework because it supports programmers with all the tools needed to build mobile applications. It consists of various packages for different actions as highlighted by Dinka et. al, (2017).

i. Ionic Creator is a platform used in building a user interface by dragging and dropping ready-made components. It was implemented in designing the final appearance of the application.
ii. Ionic View makes it very easy for users to run and share developed apps to multiple devices using simple command and before they are transferred to the official market store
iii. Ionic Market is used in sharing the mobile applications, charging a fee to download it. In addition,
iv. Ionic has credible user support along with documentation for useful information.

v. Ionic lab for testing newly developed application on and android and IOS Ionic resource provides a documentation to showcase how easily one can learn and grasp it use on mobile platforms.

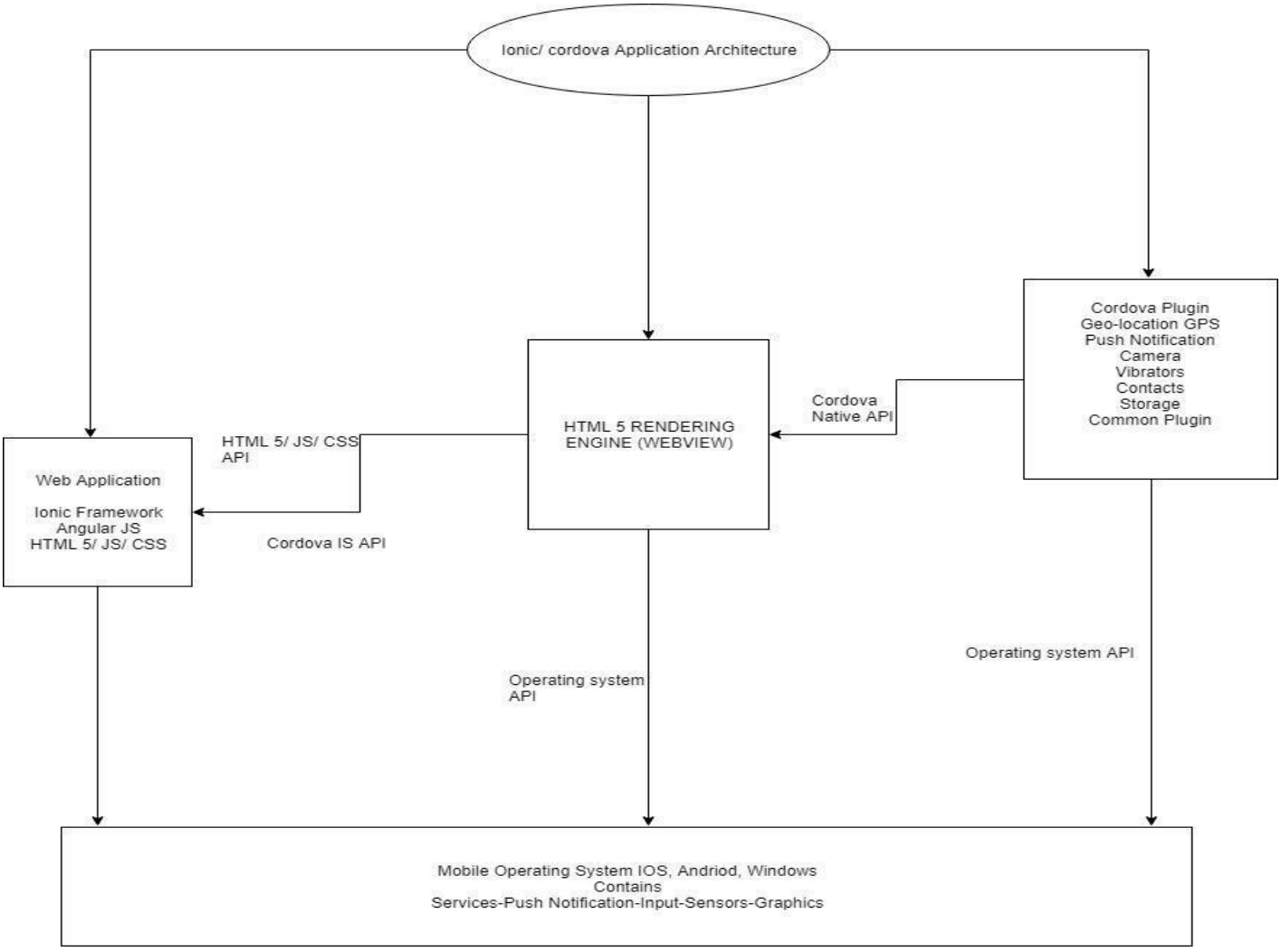


Fig: 4.1 Architecture of the proposed system (adapted from Dinka, Emmanuel & Oyeyinka, 2017).

The diagram above shows the technical components of the Ionic architecture. Since the communications between the operating system is platform dependent building process, the Cordova JavaScript API has become an important component standing between web applications the devices. It has the ability to run HTML, CSS, JavaScript as a substitute for platform specific APIs.

Cordova is the bridge that communicates between the web app wrapper has access to both the web application platform through the JavaScript API. This is primarily held behind the scene and Cordova ultimately generates the native app. This is necessary in order to run native functionalities such as Geo-location, Camera, storage, contact, vibration etc. (Anibal, 2017). Web Application cannot run such functionalities except with the help of Apache Cordova. One component of Cordova that is useful is the Cordova app wrapper that helps to load the web application code.

Angular: Angular is a very popular framework for building powerful web applications. The well application runs inside of a container known as the Web View. Angular is primarily used to manage the web application's logic and data. Angular provide components, data binding, services, forms, directives, http, dependency injections forms.

Ionic: Ionic is built on top of Angular to provide the user interface, and is primarily used to design an interactive responsive user interface. This includes the visual elements such as tabs, buttons, this interface controls are the heart of Ionic, near-native interface inside of a hybrid app. Ionic also includes a number of additional utilities your app, this ranges from creation, previewing to deployment. The combination of these technologies makes Ionic a very feature-rich platform and stands as the foundation for building reliable mobile apps.

MySQL was used for database storage, phpMyadmin serves as the database manager, google Chrome serves the need for web browser and Apache was used as the host server.

4.2 Diacare Mobile App Requirements Analysis

This phase involved getting to know and understand what users need the system to do for them and also stipulate what the system needs so as to function properly and efficiently. It involved getting to know the functional and non-functional requirements of the system.

4.2.1 Functional Requirements

This is used to describe the precise functions or actions of Diacare. The functional requirements for the app are as follows:

i. The app must have a general page in which users can access to get diabetes health care health tips, health check reminders and success stories of former Diacare users once they download, install it on their mobile devices and are connected to the internet.

ii. The app must have a register page where authorized users can enter their demographic data, check their body weight based on their Body Mass Index (BMI) and Basal Metabolic Rate (BMR) and Total Daily Energy Expenditure (TDEE) values by inputting their body weight (kilogram), height (meters), age (years) and gender.

iii. The app should be able to get feedback from users and automatically generate how many users access the system within a specified period of time.

iv. The app should be able to allow the administrator have unlimited access to the database, send health tips, send latest updates, upgrade the app, update exercises and other diabetes health care necessary information.

v. The app should be able to suggest adequate activity and food choices for users based on the type of diabetes, severity, age, medical history and other factors.

4.2.2 Non-functional Requirements

This described the app's behavior as it relates to its functionality. It elaborates the performance characteristics of the app. Most of the non-functional requirements of the system was integrated at each level of the software developmental process. The major non-functional requirement that this work will address is acceptability.

4.3 User Requirements

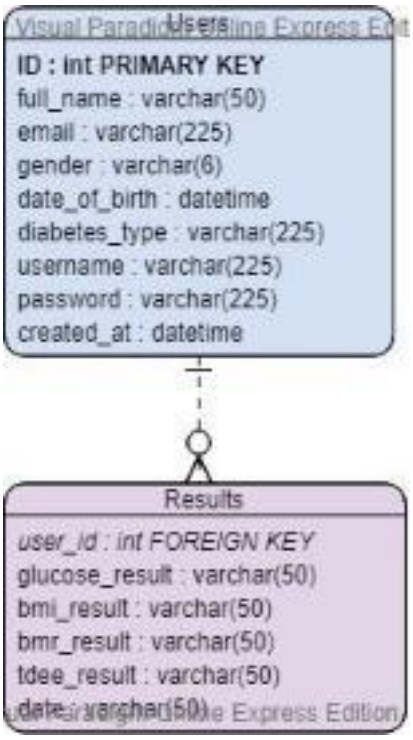
The need to know the user requirements is a vital and integral part of information system design which is essential to the success of any mobile app. The app was designed for users that need a mobile app which can assist them in managing and monitoring their diabetes level, motivate them to eat right and go for health check-ups. The app was designed to be unilingual, English being the language of choice.

4.3.1 Software and Hardware requirements

A smart phone running on any operating system platform is required since the app was designed to be cross-platform. An internet connection is also necessary for the functions of the app to be utilized maximally.

4.4 Entity-relationship model of the design

The e-learning system's entity relationship describes how documents in the database are linked to one another. At the easiest stage it produces a 1:N (one-to-many) connection between the two entities by adding a lookup field to any entity.



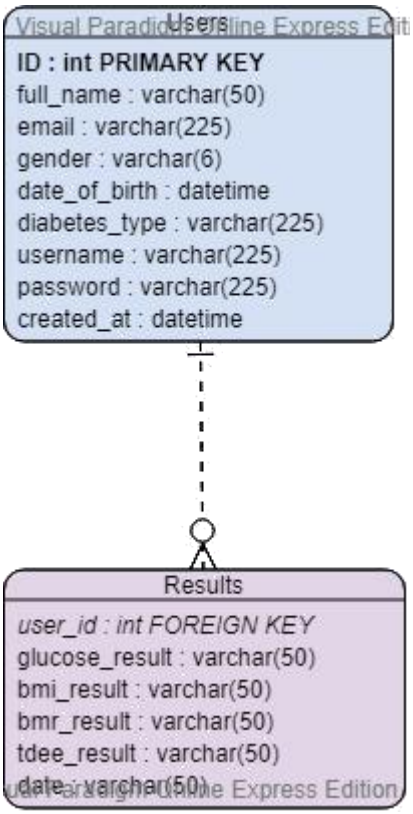


Figure 4.2: Diacare Users Entities

4.5 Screenshot of the Implementation Stage

The screenshots of the implementation stages show the different views of the users depending on their roles with a brief description of what it entails.

1) **Home Screen:** This is the first page that appears when the mobile application is launched. While on this page people can choose to register and continue to access files, resources and access the contact us page.

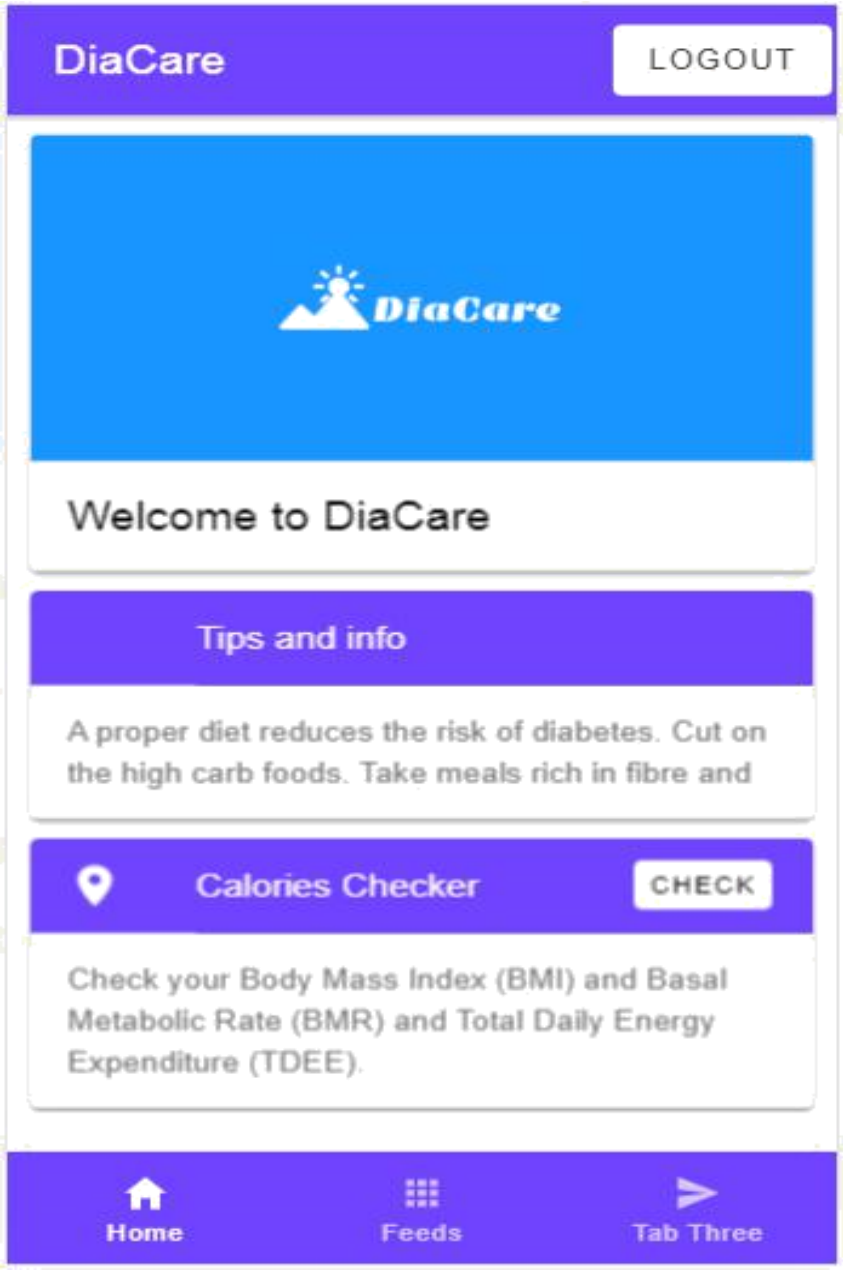


Figure 4.3 Home Screen 1

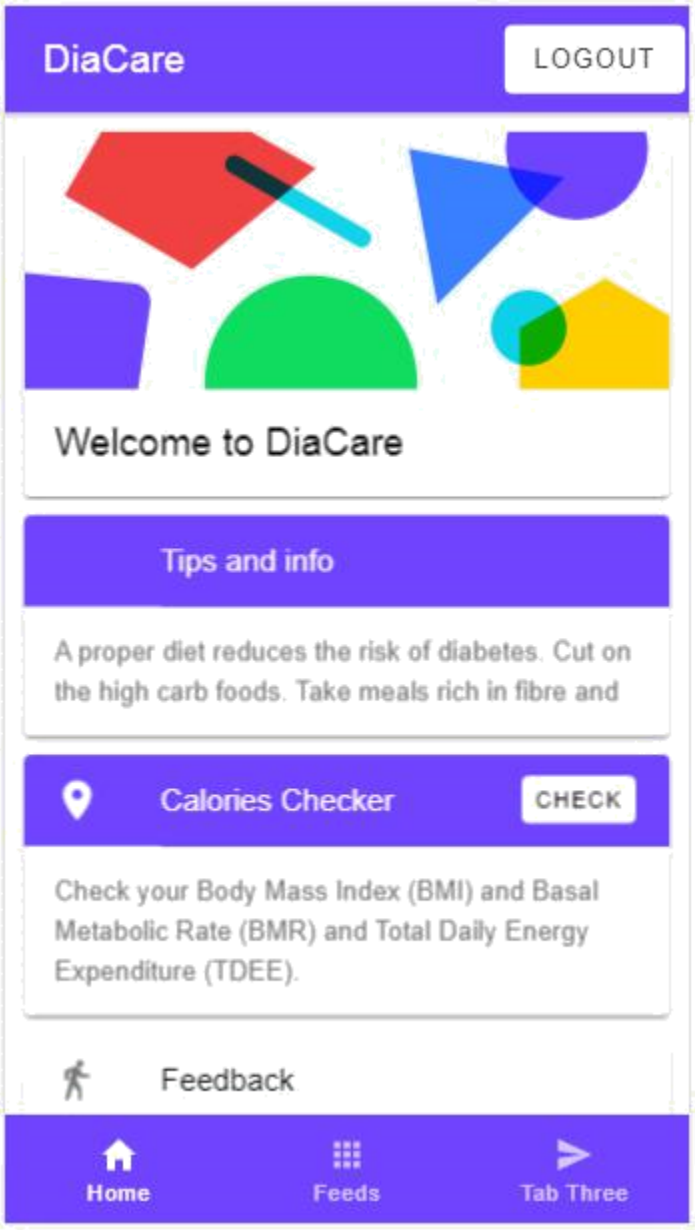


Figure 4.4 Home Screen 2

2) **Registration:** To access the mobile application modules users log in with their existing accounts or create a new account. The user must first register or be registered by the administrator. To access the registration page, the user navigates through the application on clicks on the registration button as shown below before a clicking the registration button for a successful registration.

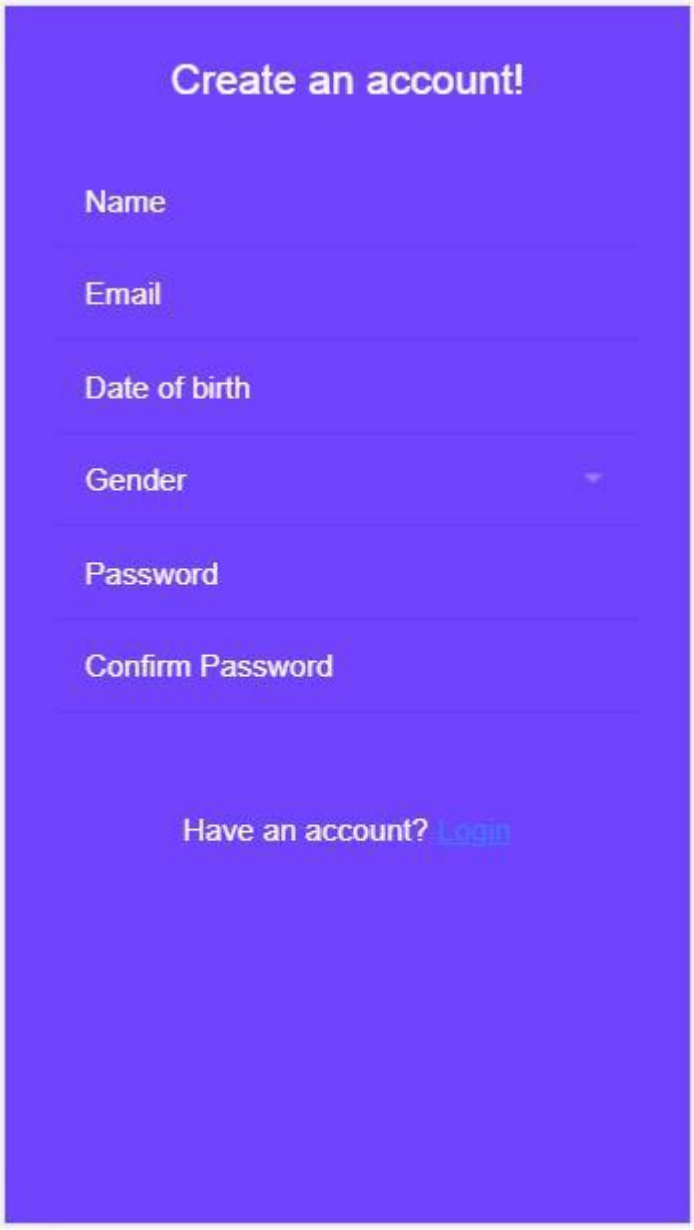


Figure 4.5 Registration Page

3) **Login Option:** The login form is used to authenticate user's credentials before given them access to their privileges. The login form contains a field for the username and another for the password. When the login form is submitted, the basic logic or code checks that the credentials are authentic, given the user access to the restricted page. If a user is not authenticated correctly, they will not be able to proceed past the login form.

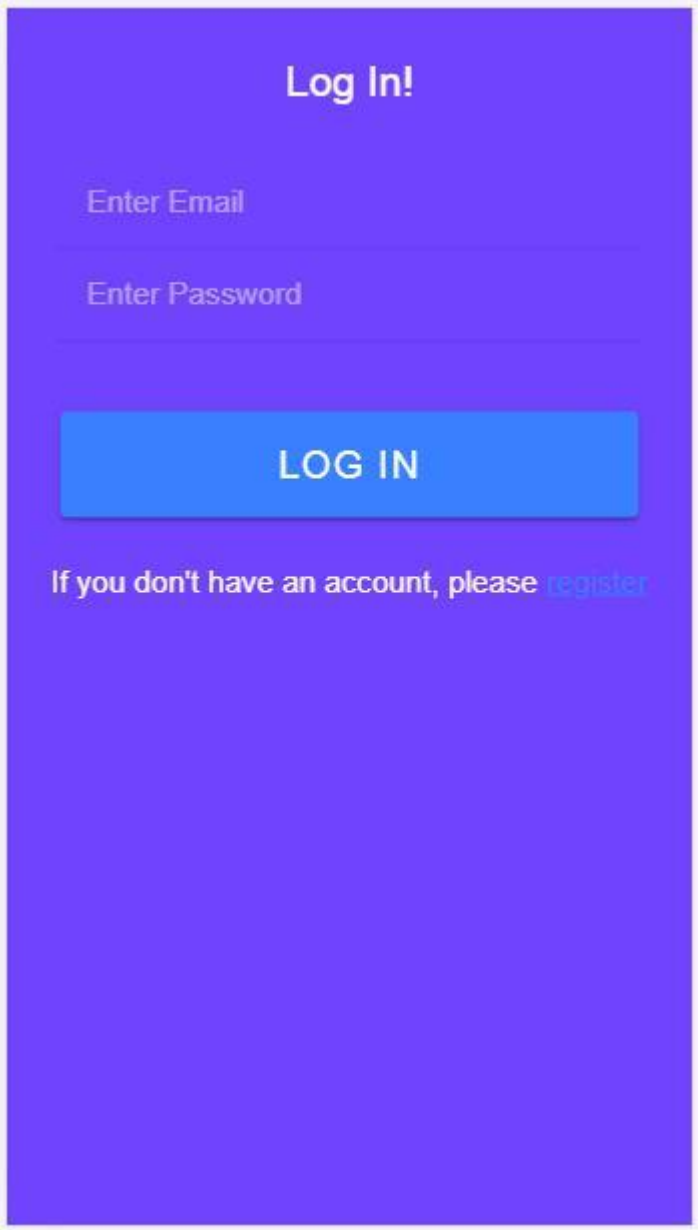


Figure 4.6 Login Page

4) **Checker:** This page checks the patient's glucose level, weight, calories burned per min, per week, check their diet plan. The required inquiry is filled in the required field and then it processes the inputted data.

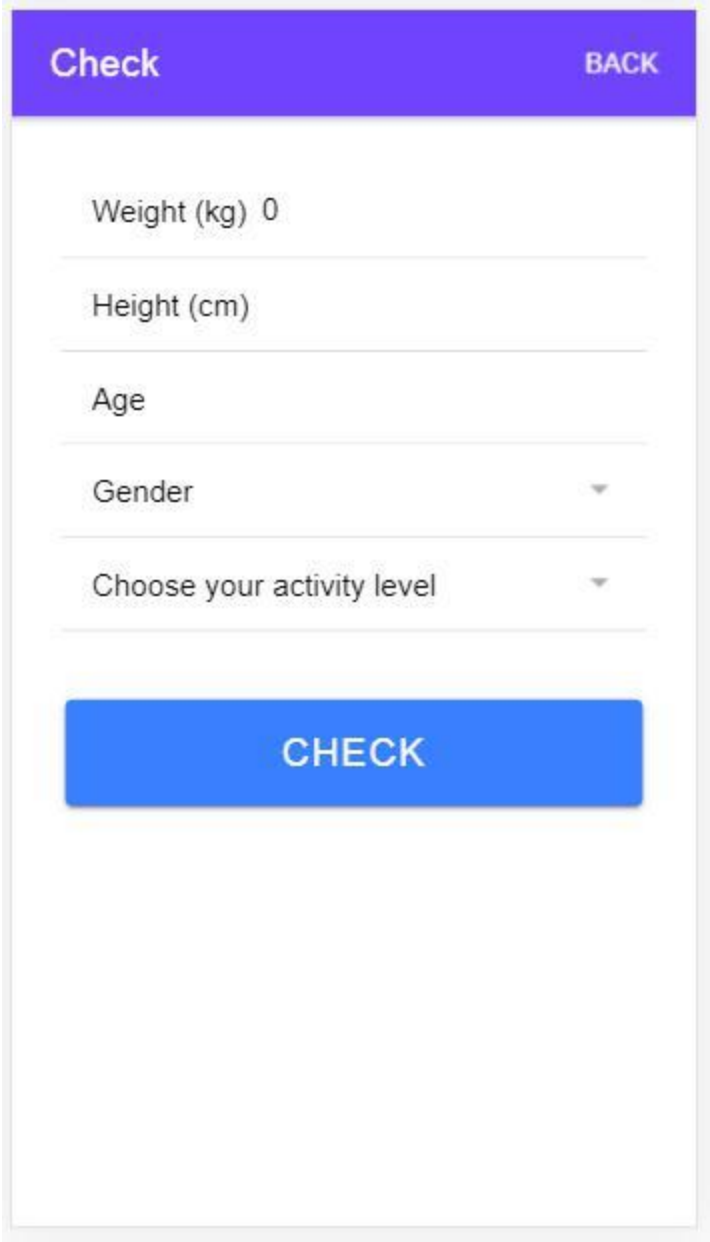


Figure 4.7 Checker Page

5) **Checker Result:** This page shows result of the requested inquiry and then shows if such patient is on the right track and if not, further gives health tips on what to do to get back on track.

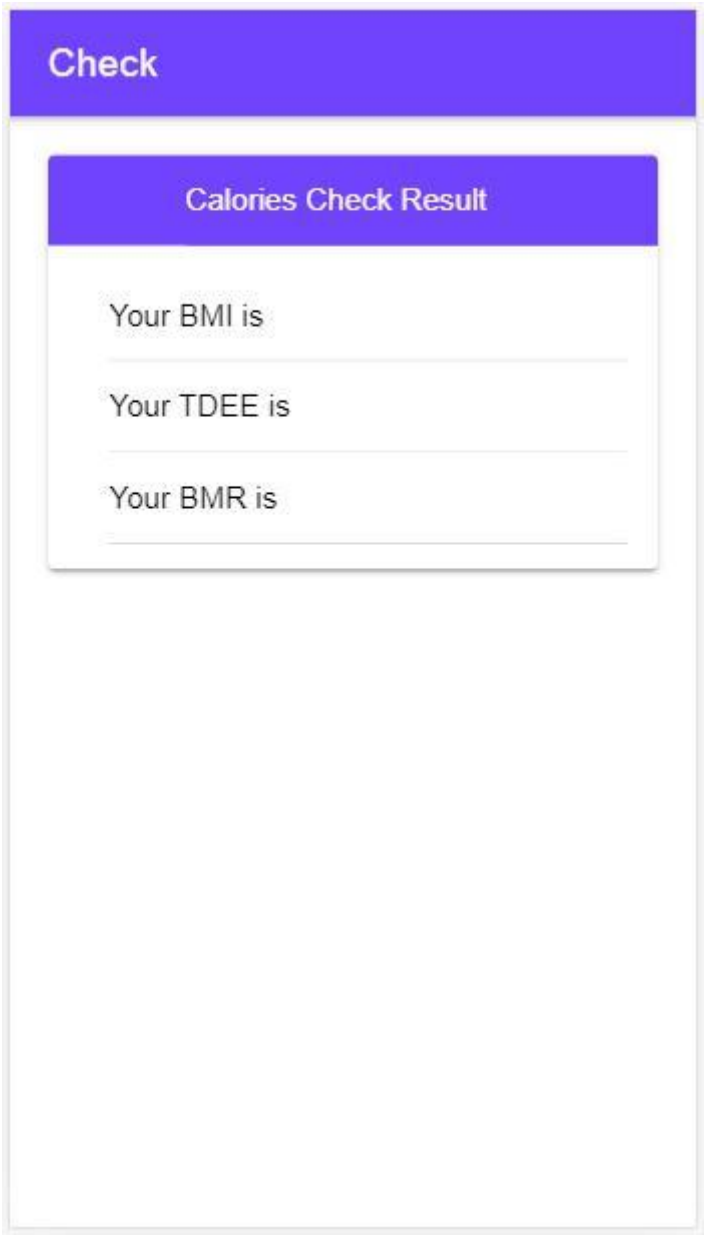


Figure 4.8 Checker Result Page

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS, AND CONCLUSION

5.0 Introduction

This chapter explains in details the summary of mobile application for diabetes monitoring and management, recommendations for further studies on mobile applications for diabetes monitoring and management and then a conclusion that discusses intended features of an improved mobile application for diabetes monitoring and management.

5.1 Summary

Diabetes is a chronic illness that requires vigilant monitoring and management of glycemic fluctuations through medication, diet, and exercise. Patients diagnosed with diabetes are often challenged by the need to incorporate these various monitoring components into their daily lives. The recent emergence of mobile technology in the health care field has made diabetes self-management apps available. These smartphone apps can allow for more accurate and convenient self-monitoring. Evidence of the benefits of smartphone apps in health care is mounting as researchers conduct and publish studies evaluating these new tools. Health Care Professionals must evaluate a wide array of factors before recommending mobile apps for their patients with diabetes. First, they should assess their patients' comfort level and proficiency with mobile technology. In general, elderly patients may require a longer period of time and more experience to become accustomed to apps and may be reluctant to use mobile technology for diabetes management. In contrast, patients with advanced technological proficiency may prefer apps. The cost associated with smartphones and apps is also an integral factor. Not all diabetes management apps are free, and the costs may pose additional financial burdens for patients. HCPs also must be aware of the different types of platforms available to consumers. Most importantly, they should tailor their recommendations to apps that address each patient's particular areas of difficulty in managing diabetes.

It is important to discuss overall goals to gain an understanding of what each patient hopes to gain by using a smartphone app. For example, some apps focus on tracking blood glucose, whereas others also include carbohydrate-tracking features. Patients' expectations should help to guide HCPs in recommending an app that best fits their lifestyle and health condition.

Patients may prefer certain apps to others based on their ease of use. The availability of other important features, such as reminders via text messages, data-sharing with HCPs, and compatibility with medical devices, is also a consideration.

5.2 Conclusion

Diabetes mellitus is one of the chronic diseases that is growing in the populaces of advanced countries. Self-monitoring is a requirement for the proper education of people with diabetes. Better education increases adherence, i.e., the extent to which patient behavior (drug use, compliance with regimens) coincides with medical advice or medical standards. However, adherence also has an impact on financial costs, as drug consumption decreases and postponements likely complications. With the current rapid development and increased use of modern technologies, mobile applications for diabetes shows that existing solutions do not provide a comprehensive service about maximum adherence. A newly intended solution that focuses primarily on ensuring features like: the option to generate statistics and charts, share data with friends, create detailed reports to share with the patient's physician, an educational module, and the option to influence the content of the application, gives the potential to increase the formation of the right habits of patients with diabetes.

5.3 Recommendations

This implementation design concentrated primarily on patients, but the way healthcare providers use this implementation can be considered in future development. Features such as uploading pictures and scrolling video suggestions should be studied using a high-fidelity vibrant prototype where the communication would imitate what a mobile device genuinely would be like. Furthermore, the app's part of the food database was not fully created. Evaluation of usability indicates that monitoring and consumption of carbohydrate is an onerous job for many gestational diabetic patients making this an environment where innovative study can be very helpful.

5.4 Limitations

The limitations encountered in the course of this work are time constraints, inability to have access to the data of diabetic patients as a result of information privacy and overlooking the needs of the population that do not own smart phones or mobile phones or even low income population that cannot afford to use this kind of technology.

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Appendix

Source code for mobile app for diabetes monitoring and management.

Model

Login Page

```
<ion-header>
  <ion-toolbar color="primary">
    <ion-title>Home</ion-title>
  </ion-toolbar>
</ion-header>


<ion-content padding>


</ion-content>


<ion-tabs>


  <ion-tab-bar slot="bottom" color="primary">
    <ion-tab-button tab="home">
      <ion-icon name="home"></ion-icon>
      <ion-label>Home</ion-label>
    </ion-tab-button>


    <ion-tab-button tab="feed">
      <ion-icon name="apps"></ion-icon>
      <ion-label>Feed</ion-label>
```

```
    </ion-tab-button>

    <ion-tab-button tab="">
      <ion-icon name="settings"></ion-icon>
      <ion-label>Settings</ion-label>
    </ion-tab-button>
  </ion-tab-bar>

</ion-tabs>
```

Register Page

```
<!-- <ion-header>
  <ion-toolbar>
    <ion-title>register</ion-title>
  </ion-toolbar>
</ion-header> -->

<ion-content color="primary">
  <ion-grid>
    <ion-row color="primary" justify-content-center>
      <ion-col align-self-center size-md="7" size-lg="7" size-
        xs="12"> <div text-center>
          <h3>Create an account!</h3>
        </div>
        <div padding>
```

```
<ion-item>
  <ion-label position="">Name</ion-label>
  <ion-input name="name" type="text" placeholder="" [(ngModel)]="name"
required></ion-input>
</ion-item>
<ion-item>
  <ion-label position="">Email</ion-label>
  <ion-input name="email" type="email" placeholder="" [(ngModel)]="email" required>
  </ion-input>
</ion-item>
<ion-item>
  <ion-label position="">Date of birth</ion-label>
  <ion-datetime display-format="YYYY / MMM / DD" min="1910-01-01" placeholder=""
value="1990-01-01"
    [(ngModel)]="dob" required>
  </ion-datetime>
</ion-item>
<ion-item>
  <ion-label>Gender</ion-label>
  <ion-select placeholder="" [(ngModel)]="gender" required> <ion-
    select-option value="Female">Female</ion-select-option> <ion-
    select-option value="Male">Male</ion-select-option>
  </ion-select>
</ion-item>
<ion-item>
  <ion-label position="">Password</ion-label>
```

```
          <ion-input name="password" type="password" placeholder="" [(ngModel)]="password"
required></ion-input>

        </ion-item>

        <ion-item>

          <ion-label position="">Confirm Password</ion-label>

          <ion-input name="confirm" type="password" placeholder="" [(ngModel)]="confirm"
required></ion-input>

        </ion-item>

       </div>

       <div padding>

        <ion-button size="large" type="submit" (click)="register()"

        expand="block">Register </ion-button>

       </div>

     </ion-col>

     <div text-center>

       Have an account? <a routerLink='/register'>Login</a>

     </div>

   </ion-row>

  </ion-grid>

</ion-content>
```

Home Page

```
<ion-header>

  <ion-toolbar color="primary">

    <ion-title>

      DiaCare
```

```
    <!-- <ion-img [src]="assets/icon/android/mdpi.src"></ion-img> --
   > </ion-title>
    <ion-button fill="" slot="end">Logout</ion-button>
  </ion-toolbar>
</ion-header>

<ion-content>

  <ion-card color="primary">
    <ion-card-header>
      <ion-card-title>Welcome to DiaCare</ion-card-title>
    </ion-card-header>
      <ion-card-content>
        Get daily tips and news on diabetes
      </ion-card-content>
  </ion-card>

  <ion-card>
      <ion-item color="primary">
        <ion-icon name="" slot="start"></ion-icon>
        <ion-label>Tips and info</ion-label>
      </ion-item>

      <ion-card-content>
```

A proper diet reduces the risk of diabetes. Cut on the high carb foods. Take meals rich in fibre and

</ion-card-content>

</ion-card>

<ion-card>

<ion-item color="primary">

<ion-icon name="pin" slot="start"></ion-icon>

<ion-label>Calories Checker</ion-label>

<ion-button fill="" slot="end" (click)="check()">Check</ion-button>

</ion-item>

<ion-card-content>

Check your Body Mass Index (BMI) and Basal Metabolic Rate (BMR) and Total Daily Energy Expenditure (TDEE).

</ion-card-content>

</ion-card>

<ion-card>

<ion-item>

<ion-icon name="walk" slot="start"></ion-icon>

<ion-label>Feedback</ion-label>

</ion-item>

```
  </ion-card>

  <ion-tabs>

    <ion-tab-bar slot="bottom" color="primary">
      <ion-tab-button tab="" href="">
        <ion-icon name="home"></ion-icon>
        <ion-label>Home</ion-label>
      </ion-tab-button>

      <ion-tab-button tab="" href="feed">
        <ion-icon name="apps"></ion-icon>
        <ion-label>Feed</ion-label>
      </ion-tab-button>

      <ion-tab-button tab="tab3">
        <ion-icon name="settings"></ion-icon>
        <ion-label>Settings</ion-label>
      </ion-tab-button>
    </ion-tab-bar>

  </ion-tabs>

</ion-content>
```

Checker Page

```
<ion-header color="primary">
  <ion-toolbar>
    <ion-title>Calories Check</ion-title>
    <ion-buttons slot="primary">
      <ion-back-button text="Back" icon="" color="tertiary" fill="outline"></ion-back-button>
    </ion-buttons>
  </ion-toolbar>
</ion-header>

<ion-content>
  <ion-grid>
    <ion-row color="primary" justify-content-center>
      <ion-col align-self-center size-md="7" size-lg="7" size-
        xs="12"> <div padding>
          <ion-item>
            <ion-label position="">Weight (kg)</ion-label>
            <ion-input name="weight" type="text" placeholder="" [(ngModel)]="weight"
required></ion-input>
          </ion-item>

          <ion-item>
            <ion-label position="">Height (cm)</ion-label>
            <ion-input name="height" type="text" placeholder="" [(ngModel)]="height" required>
```

```
  </ion-input>
 </ion-item>

 <ion-item>
  <ion-label position="">Age</ion-label>
  <ion-input name="age" type="text" placeholder="" [(ngModel)]="age" required></ion-input>
 </ion-item>

 <ion-item>
  <ion-label>Gender</ion-label>
  <ion-select placeholder="" [(ngModel)]="gender" required> <ion-
   select-option value="Female">Female</ion-select-option> <ion-
   select-option value="Male">Male</ion-select-option>
  </ion-select>
 </ion-item>

 <ion-item>
  <ion-label>Choose your activity level</ion-label> <ion-
  select placeholder="" [(ngModel)]="activity" required>
   <ion-select-option value="Sedentary">Sedentary (little or no exercise)</ion-select-option>
   <ion-select-option value="Lightly active">Light exercise/sports 1-3 days/week</ion-select-option>
   <ion-select-option value="Moderately active">Moderate exercise/sports 3-5 days/week</ion-select-option>
```

```
            <ion-select-option value="Very active">Hard exercise/sports 6-7 days a week</ion-select-option>

            <ion-select-option value="Extremely active">Very heavy exercise/pysical job</ion-select-option>

          </ion-select>

        </ion-item>


      </div>

      <div padding>

        <ion-button size="large" type="submit" (click)="calc()"

        expand="block">Check </ion-button>

      </div>

    </ion-col>

  </ion-row>

 </ion-grid>

</ion-content>
```

Tab Display

```
<ion-header>

  <ion-toolbar color="primary">

    <ion-title>Home</ion-title>

  </ion-toolbar>

</ion-header>


<ion-content padding>
```

```
</ion-content>

<ion-tabs>

  <ion-tab-bar slot="bottom" color="primary">
    <ion-tab-button tab="home">
      <ion-icon name="home"></ion-icon>
      <ion-label>Home</ion-label>
    </ion-tab-button>

    <ion-tab-button tab="feed">
      <ion-icon name="apps"></ion-icon>
      <ion-label>Feed</ion-label>
    </ion-tab-button>

    <ion-tab-button tab="">
      <ion-icon name="settings"></ion-icon>
      <ion-label>Settings</ion-label>
    </ion-tab-button>
  </ion-tab-bar>

</ion-tabs>
```