A Software Approach to Managing Dietary and Health Needs of Diabetic Patients in Nigeria

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***Abstract*: Some of the challenges diabetic patients face in Nigeria include the unavailability of health care providers, costly healthcare services and monitoring. Also, many are unaware of the effect of diet planning and daily health monitoring in managing this life-threatening condition. Diabetics can largely gain from an effective home care management system and also from a community of patients and caregivers. This will especially help new patients to acquire more knowledge about this health condition and understand how to live with it. In this paper, we present a cost effective solution to managing diabetes, in form of a home care mobile application. Firstly, we present a design of a system used for diet planning, health information and planning. In addition, a community forum is designed for diabetes support. The implementation of an android version of the design is further presented in the paper. This was achieved using the Dart programming language and Javascript on Flutter framework. The visual studio Integrated Development Environment (IDE) was used for easy integration of the software.**

***Keywords*: Diabetes, Diet planning, Flutter, Dart, BMI**

I. INTRODUCTION

Diabetes is a chronic disease affecting millions of lives. It is a condition that impairs the body's ability to process blood glucose [1]. Two major types of diabetes; type 1 (also known as juvenile diabetes) and type 2 mostly occurring in older adults, affects people living in Nigeria. A third type is the gestational diabetes which occurs more often in pregnant women. Diabetes if not properly managed can result to complications leading to death. It has been found to be a major cause of heart attack, stroke, blindness, kidney failure and amputations of the lower limbs. Diabetes was the 9th leading cause of death in 2019, resulting in the death of about 1.5million people [2]. The World Health Organization believes that a healthy diet, regular exercise and the ability to maintain a normal body weight while avoiding the use of tobacco can prevent or even delay the onset of type 2 diabetes. They also stated that diabetes can be treated with diet, physical activity, medication, regular screening and treatment for complications [2].

The advancement in technology has affected every aspect of human endeavors including health and diet. This has been evident in the increased production of processed foods, leaving numerous options for dieting. Because of rapid urbanization, busy schedules, and lifestyle change, there is a proportional change in diet. Another aspect of this is that suffering from malnutrition may not necessarily mean a lack of adequate foods that should be healthy for the body but a lack of knowledge of how they can be used as healthy diets [3]. The result of a lack of attention to healthy food consumption [4] is exposure to all kinds of diseases caused by malnutrition or non-healthy diets. However, the prevention of all forms of malnutrition that can easily be noticed in a range of non-communicable diseases can easily be achieved through dietary management. At this point, dietary management can be seen as the ability to offer control on nutritional options made available for people with diet issues.

The use of a software is feasible for dietary management, especially where it concerns diabetic patients. Software in itself represents the combination of interrelated programs aimed at solving a particular problem. Since, what people eat has a direct consequence on the level of sugar in their blood [5], healthy eating is paramount and most appropriate for managing diabetes with its blood sugar fluctuations. To ensure healthy eating, it becomes important to avoid any form of nutritional imbalance in the body system. This can only be achieved through a well-organized and watchful nutritional balancing with consistent monitoring of biochemical control [6]. Given this, the authors in [7] developed a software that facilitates an automated system for preparing dietary prescriptions for diabetes management because it has the capability of calculating the required nutritional values and subsequently generates daily menus for patients without human intervention. Another benefit of using software to manage the health of a diabetic patient is in [8], given the accurate data collection, analysis, and description of the dietary patterns and nutrient intakes of the patient.

This project was embarked upon in order to help diabetics and caregivers properly manage this condition. By making it easier for them to access new and existing recipes, guiding them in the right proportions of daily meal from the calculations of their vitals, all to be implemented as a single module of diet management. The software also includes a Body Mass Index (BMI), Lean mass and Body fat calculators for proper health records and advisory, and finally a forum to enable patients communicate with their doctors and other diabetics across the nation. All of these is to enable proper home care and management of diabetes in Nigeria.

The structure of this paper firstly presents a review of existing Information Technology and computing based

solutions for managing diabetes. In the later part of this work the design and implementation of a mobile application for the management of dietary and health needs of a diabetic is presented.

II. BACKGROUND TO THE STUDY

Diabetes: A chronic disease that occurs when the body does not make enough insulin or when the body cannot make effective use of the insulin it produces.

Dietary Planning determines the amount of nutrient a person should take.

BMI which is Body Mass Index is derived from the height and weight of person usually used to tell if a person's weight is healthy.

$$BMI = Weight\ (Kg)/Height\,(m^2)$$

Body Fat Measurement enables a person calculate the amount or percentage of body fat present in their body. It gives the loss needed to reach ideal body weight.

Lean Body Mass (LBM) also called lean mass, gives the difference between entire body weight and body fat weight. This means that the LBM will include the weight of organs, bones and muscles in the body.

A. Review of Related Works

There is one thing most diabetes management applications have in common, managing data about patient's health information and lifestyle which may include blood glucose, BMI, diet and exercise. The researchers in [9]-[11] developed a Personal Digital Assistant (PDA) for this purpose. While [12] and [13] worked on developing applications that work on android and the web, [14] and [15] developed expert systems and rule based algorithm respectively, for the analysis and management of diabetics' health data.

The authors in [12] developed an android software for treating and diagnosing people with diabetes. They also implemented a module to save and retrieve patients report. In [13], a web application called GIGISim was implemented for the purpose of managing diabetes mellitus in patients using a collection of multiple healthcare tools.

An expert medical system was developed by [14], which helps in diabetes management, it also stores clinical data of patients such as insulin dosage, diet and exercise routine of patients. In order for the doctors to easily manage their patients while far away from them. Their system also makes recommendation to patients. In their study, [15] implemented a cost effective knowledge based system for self-management and diagnosis of diabetes. Their system runs as a rule based using Prolog programming.

In their paper, [9] developed a mobile application that serves as a personal digital assistant (PDA) to diabetic patients for the purpose of managing individual's data such as diet, exercise and blood glucose. It also indicates Body Mass Index, diabetes index and predicts body weight. In order to determine how self-monitoring with PDA devices can be integrated with SC-based intervention the authors in [10], carried out a study in which they also looked into the possibility of adapting PDAs for self-monitoring patient's meals. A rule based system using K Nearest Neighbor algorithm was developed by [11] to obtain the best treatment procedures for diabetics. This system stores health information about diabetic patients, further recommends and monitors food consumption and physical activities. The authors also developed a PDA for monitoring purpose.

Other notable works are those of [16], who developed a system that enables the management and reporting of glucose level information over a wireless means to a remote server. In addition, [17] came up with DialBetics, a system for diabetic data transmission, evaluation and communication. They further studied a group of 54 patients to determine the safety and usability of their system.

B. Technologies Used

The mobile application in this study was developed for an Android environment using the Flutter framework, with programming languages such as Dart and Javascript. The Firebase google cloud platform was used in the implementation of the back end. In realizing the project, a specifically built Integrated Development Environment (IDE) known as Visual Studio Code was used.

1) Android Technology: Android is a mobile operating system developed by Google, it is used by several smart phones and tablet and the Android Operating System (OS) is based on the Linux kernel. It is the most popular mobile OS in Nigeria. Some justification for the use of android technology in this work is its flexibility, availability and security for end users.

2) Flutter Framework: Flutter is Google's mobile app Software Development Kit (SDK), complete with a framework, widgets and tools. Flutter gives developers an easy way to build and deploy fast, aesthetically-pleasing mobile apps – on both Android and iOS platforms – with as little overhead as possible. Flutter widgets made the development simple, productive and fast. These widgets are so easily customizable that you can create effortlessly almost anything you can imagine.

3) *Dart Programming Language:* Dart is a client-optimized language for fast apps on any platform made by Google. It compiles to ARM & x64 machine code for mobile, desktop and backend. It can also compile to JavaScript for the web. Dart is also a programming language optimized for building user interfaces with features such as the spread

operator for expanding collections, and collection if for customizing UI for each platform. Dart is AOT (Ahead of Time) compiled to fast, predictable, native code, which allows almost all of Flutter to be written in Dart. This not only makes Flutter fast, virtually everything (including all the widgets) can be customized.

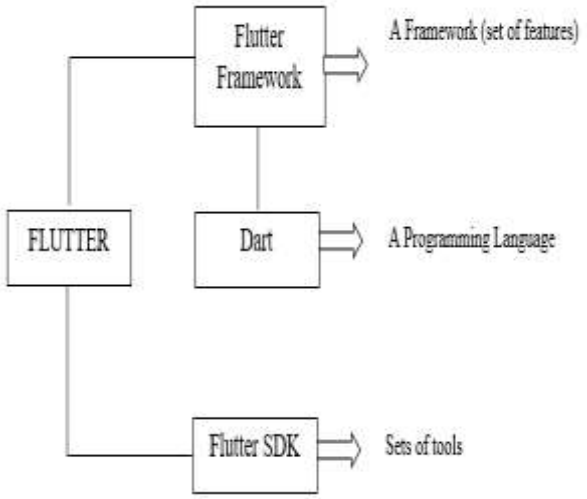

Fig. 1 Overview of the Flutter Framework

4) *Firebase Real-Time Database*: This is the database that will be used for this project. It is a mobile and web development environment acquired by Google in 2014. Firebase apps remain responsive even when offline because the Firebase Real-time Database SDK persist your data to disk. Once connectivity is reestablished, the client device receives any changes it missed, synchronizing it with the current server state. The Firebase Real-time Database can be accessed directly from a mobile device or web browser; there is no need for an application server. Security and data validation are available through the Firebase Real-time Database security rules, expression based rules that are executed when data is read or written.

5) Visual Studio Code: Visual Studio Code runs on multiple platforms, it is lightweight and a powerful source code editor that runs on your desktop. Visual studio code is a premium Integrated Development Environment (IDE), which enables users set their preferences such as themes and installation of extensions for added functionality.

III. METHODOLOGY

The methodology adopted for this project is the Object Oriented Analysis and Design Methodology (OOADM). This methodology considers the world as an entity that can be modelled considering the objects and events happening around us. The analysis includes that of the existing system/approach and the proposed system. The design herein consists of a use case diagram, class and activity diagrams. The reason for choosing this methodology is because of its simplicity and ability to easily model real world entities.

A. Drawback of the Existing System

Some challenges with the existing systems is that it cannot be integrated into the Nigerian community; the meal plans are based on foreign recipes and ingredients not available in Nigeria and the lifestyle definitions doesn't fit Nigerians. Some use a different metrics system not familiar to those in the rural parts of the country. It also doesn't cover the computation of lean mass and body fat required for patients to obtain optimum weight. Generally, appropriate nutritional treatment, implementation and ultimate compliance with the plan remain some of the problems in the diabetic management for many reasons such as; Nutritional science is constantly evolving, so that what may be considered true may be outdated in the near future. Also, there is no perfect agreement among professionals as to the best nutritional therapy for individuals with diabetes. Lastly, wide real-life experimentations are not performed yet.

B. Analysis of the Proposed System

The proposed system serves as an improvement on the existing solution. In addition to calculating BMI, it calculates and keeps track of the lean mass and body fat of users, enabling them know how much calories needs to be cut off and how much exercise is required to meet their targeted weight. The diet planner is focused on Nigerian dishes and allows users customize their meals based on updated recipes and available ingredients. The application monitors carbs and daily percentage intake of the required nutritional needs. The system is intended for deployment in a real life setting to be used and tested by diabetics in Nigeria. The system has three modules; diet planner, health calculators and the community forum.

C. System Architecture

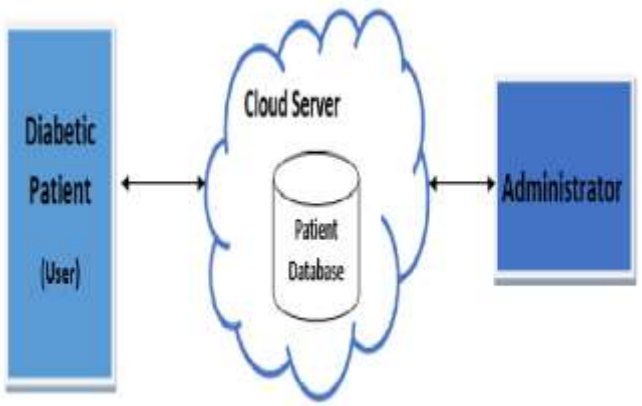

Fig. 2 System Architecture

The main user of this system is the diabetic patient, but in case of older or weaker patients interactions with the software can be made by a relative or caregiver. The administrator handles the management and upload of data to the cloud, such as new dietary plans, moderation of the community forum, software updates etc.

Patient database contains dietary and health information. It also stores chats and communication between patients and doctors. A community chat is enabled for people with diabetes, which also serves as a support group.

D. Implementation Architecture

The implementation architecture gives an overview of the modules and sub-modules to be created in the process of developing this system. It also shows the relationship they have with each other.

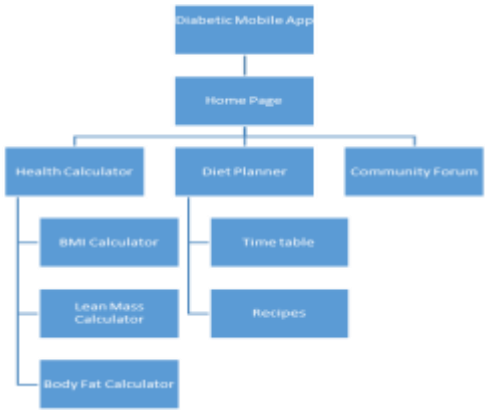

Fig. 3 Implementation Architecture

E. Choice of Development Environment

The system was developed using Visual Studio Code Environment, Flutter as the framework and Dart as the programming language. Flutter is Google mobile SDK, complete with a framework, widgets and tools that gives developers an easy way to build and deploy visually attractive, fast mobile apps on both Android and iOS platforms. Flutter enables a smooth and easy cross- platform mobile app development. The architecture of Flutter is based on the very popular reactive programming of nowadays. Flutter provides its own widgets, drawn with its own high performance rendering engine, they are fast, pretty and customizable.

IV. RESULTS AND DISCUSSION

. The screenshots from the resulting system i.e. the android mobile application developed in this study is presented in this section. The application was tested by selected users to ensure that the components are working properly. Proper documentation and user manual was developed to guide new users and researchers on the working principle of the application.

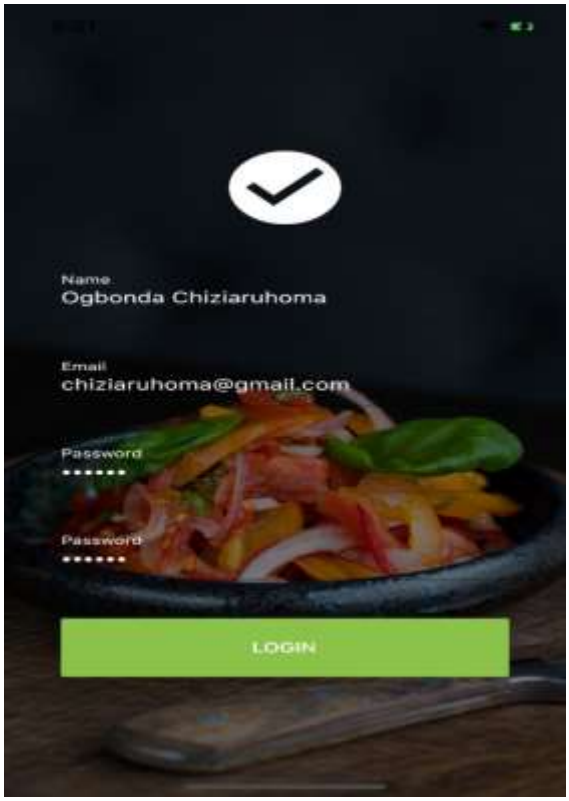

Fig. 4 Login page

Fig. 4 shows the login page, used to control access to user accounts. Here a user tries to login using his credentials, which includes name, email and password. This verifies the user's registration to access the application.

Fig. 5 Community Forum

Fig. 5 shows sample chat messages in the forum. The community forum shows chat messages from user to other participants, who can be either diabetics or caregivers. The community forum is for individuals living within a specified geographical location, this helps to guide interaction and suggestions shared between users of similar environment and lifestyle to share ideas and resources that may of value to other members. This may include information on recipes, exercise, lifestyle changes and new technologies that aid healthy living.

Fig. 6 Health Calculator Options

Fig. 6 shows the three health calculators, their icon and the description of each calculator. The health calculator helps with BMI, Lean Mass and Body Fat computation. It is believed that these three computations are relevant for optimum health benefits. Users can choose to obtain any of these values using the labelled icons.

Fig. 7 BMI Calculator

Fig. 7 shows the input variables for BMI calculations. User selects height, weight and gender and the software computes BMI using the values selected. To reduce errors from input values, users are guided to select from a range of given value instead of typing in values as are common in some calculators.

Fig. 8 BMI Result Page

Fig. 8 shows the result of BMI computation. The application also advises patients on whether they are within the specific weight range for their body size. In other words, patients are guided to know if and when they reach their target BMI and body weight for healthy living.

Fig. 9 Lean Mass Result Page

Fig. 9 shows the result of computing lean mass index, after user has inputted the required variables.

A. Software Testing

Software testing is a process used to evaluate the functionality of a software application with an intent to find whether the developed software met the specified requirement or not to identify defects to ensure that the product is defect free in other to produce the quality product. Different tests were carried out during the implementation of this work, amongst which were the unit testing, system testing, functional testing and user testing.

1. Unit testing: The unit testing was done to check whether the individual modules of the source codes are working properly.
2. System testing: The system testing was done to fully test the integrated application to ensure the software works in all intended targeted systems. The system testing done also verified the desired output also testing the user experience with the application.
3. Functional testing: The functional testing was done to verify that each function of the software application behaves as specified in the requirement documents.
4. User testing: User testing was done among some selected diabetic patients in Nsukka to use and have a feel of the software. The response gotten from the users was that it was very interactive and easy to use. They also enjoyed the user experience they got while testing the software.

V. CONCLUSION

A software for the management of diabetics' health and lifestyle in Nigeria was developed. The software developed serves as both a prototype and initial version of this application. The solutions proffered were intended for the Nigerian diabetic community, however it may also be deployed outside this community. In the rural areas of Nigeria where access to good hospital facilities are rare, one can easily manage dietary needs and necessary health information from home, with the opportunity of connecting to their doctors through the community forum. However, this application does not replace the need for the occasional one-on-one physical visit to the doctors. It is only meant to aid the management of patients while at home and reduce hospital visits. Since the database is in the cloud doctors can request for patients data to be downloaded and sent to them. Users can also receive support from the community forum. Future work intends to extend the capability of this software to the role of monitoring, by creating additional modules to monitor insulin administration and exercise activities of patients by the use of wearable devices, with its user interface accessed through the software developed in this work. Creating user privileges for doctors to directly access the database, assigning roles and authorizations to users. By introducing user privileges and role authorization, it becomes easier to manage what each user (doctor, patient or caregiver) can access or view at any point in time for the purpose of safety and security of health data.

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