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Design and Implementation of an Intelligent Android-Based Expert System for Diet Recommendation

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Abstract

It is very obvious that people are becoming much concerned about eating healthier food, avoiding junk food, and consciously watching their weight. This reality has resulted in a rise in the need to consult an expert in human nutrition. These experts are simply referred to as nutritionists, who specialize in human nutrition and the regulation of diet. They give advice on what one should eat to remain healthy. Nutritionists help patients by monitoring and altering their nutrition based on health conditions and individual needs. However, most individuals find it difficult to visit consultant nutritionists in health centers for information about their nutritional needs while the majority encounter problems while trying to obtain nutritional information from a distant health care center; in addition there is the inability of persons to afford the cost of consulting a private nutritionist and the unavailability of frequent health monitoring services. Therefore, the need to design and implement an android-based smart nutritionist capable of making diet recommendations based on users' responses to questions asked by the system. This is possible via the integration of a dynamic database system that acts as the knowledge base and a complete model of an expert system to portray sample analysis. This knowledge base can be updated from a user interface meant for this purpose. This aim was achieved via developing an algorithm for the developed Graphical User Interface (GUI) for data collection from users and other human interaction; this was made possible using the waterfall model and object-oriented design methods. The code was realized in JAVA programming language and XML. The system was deployed and tested using a Smartphone (Infinix X624B) an android powered mobile device built by Infinix Mobile, and the developed system yielded an accurate result.

Keywords: Estimated Energy Requirement, Smart Nutritionist, Expert System, Body Mass Index

1.0 Introduction

In our world today, obesity and ill-health are resultant effects of poor nutrition which has invariably reduced the longevity of the citizenry in various societies (Kimani-Murage, 2013; Reddy *et al*., 2012; Monyeki*et al*; 2012). Some causative factors of poor nutrition that this project work will attempt to unravel include difficulties encountered by persons in obtaining nutritional information from a distant health care center; the inability of persons to afford the cost of consulting a private nutritionist; unavailability of frequent health monitoring services; and most importantly, poor eating habits of many individuals. People are becoming much more concerned about eating healthier food, avoiding junk food, and watching their weight. This has resulted

in a rise in the need to consult experts in human nutrition. In spite of this, most individuals find it difficult to visit consultant nutritionists in health centers for information about their nutritional needs. To resolve this issue and help people in improving their nutritional needs, this work is intended to design and implement a smart nutritionist for diet recommendations. The system is an android-based application for smartphones and offers smart features that evaluate the nutritional condition of an individual by assessing their physical characteristics and eating habits based on the user's inputs.

2.0 Literature Review

A. Diet Recommendation: In the research work conducted by Gergely Kov´asznai (2011) menu construction is a vital task for institutions that need to plan menus within certain constraints. Also, there is an individual need for professional menu construction by clients or patients who are expected to eat according to a planned diet. The research work showed that for menu construction and dietary analysis, there are several approaches which include linear programming, genetic algorithms, rule-based expert systems amongst others. In the research, a case-based approach for diet recommendation was proposed. Based on the selected approach, they constructed an expert system that was intended to be employed in a health record management system. The approach was based on ripple down rules (RDR), however, a special representation was also needed for patient attributes and rule actions.

B. Danes: an abbreviation for Diet and Nutrition Expert System for meal management and nutrition counseling was proposed by Gupta *et al* (2017). Their proposed system was a responsive android application that contained the knowledge and data regarding the fitness of a person and nutrition content values. The application consisted of a user interface which publicly displayed on the application i.e. the basic information regarding the fitness and nutrition values such as how to maintain good health by adopting healthy eating habits which includes the intake of calories, proteins, carbohydrates, vitamins, minerals, and much water in proper proportion. A dietician consults a person based on his schedule, body type, height, and weight. The systems request as input all this data from the user and process them. It also requests how many hours the user works, his height, weight, age, sex and activity level. The system stores and processes these data and then calculates the nutrient value needed to fill up the user's needs.

C. NUTRITION UCR: In a research work conducted by Quesada and Jenkins (2013), they described **NUTRITION UCR** which is a prototype expert system for human nutritional diagnosis developed in Java on Android using a service-oriented architecture. The system ran on mobile devices and offered smart features that evaluated the nutritional condition of an individual by assessing their physical characteristics and eating habits. In this work, the authors explained the knowledge engineering process used to develop the system. They also presented the overview of the system architecture and the selected design tools, and finally summarized some preliminary results from the prototype implementation.

D. Diet Expert System Employing Linear Programming: Van Der Merwe *et al* (2015) proposed models in a rule-based inference engine. In their research work, an expert system was built with the aim of solving multiple facets of the diet problem, by creating a rule-based inference engine consisting of goal programming- and multi-objective linear programming models. The program was successfully applied to cases specific to South African teenage girls, which were obtained through system development. The resulting system compiles an eating plan for a girl that conforms to the nutritional requirements of a healthy diet including the personal food

preferences of the girl, and consists of food items that result in the lowest total cost. Also, the system allows prioritization of the food preference and least cost factors by means of weighted priorities.

E. Expert Diet Prescription System: Ma'aruf and Garba (2012) proposed a system that was capable of identifying ailments by their name or symptoms, and returns results by prescribing an appropriate diet corresponding to ailments. From their research, it was observed that the introduction of an expert diet system has become very necessary because of the long-term devastating effect of drugs either as a result of drug abuse or its reaction on certain patients with exceptional cases. Therefore, they concluded that this will readdress the issue of adverse reaction of drugs, by the use of food/fruit as an alternative treatment to drugs.

F. Android Platform Diet Expert System: Shwetha *et al* (2020) proposed an expert system. The research work proposed an intelligent agent, called the personal dietician agent, based on users' characteristics and specifications. The personal dietician agent can develop a meal plan according to a person's lifestyle and particular health needs. Based on the results, the experts recommend eating a wide variety of foods, including vegetables, whole grains, fruits, non-fat or low-fat dairy products, beans, lean meats, poultry, and fish. Nevertheless, each person has a unique dietary pattern and has different health issues so a dietician creates a meal plan depending on each case. The dietician system is an application with artificial intelligence about human diets. It acts as a diet consultant similar to a real dietician. This system acts in a similar way as that of a dietician. The system asks for all this data from the user and processes it to provide the diet plan to the user. Thus, the user does not need to visit any dietician which saves time and the user can get the required diet plan with just a click of a button.

G. TeleHealth: Charles R Doarn et al (2019) presented a research paper on the development system built using an open-source web-based expert system framework called Tohu. The proposed expert system functions by providing individualized diet and health recommendations to users based on each user's responses to a simple auto-reporting questionnaire. A comparison is given between the development and features of this system and similar systems. A description of the system development illustrates how a complex web-based expert system can be easily constructed using open-source tools such as JBoss, Drools and Tohu.

H. In a workshop on genetic and evolutionary computation, Kahraman and Seven (2005) presented a paper on a computer system that utilized the branch-and-bound method to minimize diet in terms of cost, while attempting to include most of a certain individual's food preferences. Lanfranco *et al* (2012) developed a program that could be used to evaluate the average dietary needs in a typical Mozambican household and present a healthy diet for such a family. Although the system provided feasible solutions regarding dietary constraints and requirements, the resulting diets were not generally very affordable.

I. Smart Dietician Based on Artificial Intelligence: Pruthi*et al* (2017) developed a smart dietician that consisted of a user interface that publicly displayed the basic information regarding eating some food products which includes calories, proteins and carbohydrates, vitamins, and minerals. It also displayed information on fitness such as how to maintain good health by doing some workouts. The research paper gave an overview of modules developed in the system. According to their research, the online artificial dietician is a bot with artificial intelligence about human diets. It acts as a diet consultant similar to a real dietician. Dieticians are educated on the nutrient value of foods. A dietician consults a person based

on his schedule, body type, height, and weight. The system gets all these data from the user and processes them.

J. Food-Based Dietary: Ferguson *et al* (2004) developed a system using a four-stage linear programming model for people living in Malawi. The solution consisted of a goal-based programming model that enhanced energy contribution and also included food items that are commonly consumed in the country. The research work successfully led to a nutritionally balanced diet that incorporated food items frequently consumed in a specific region of the country.

K. Fuzzy Numbers: Another thought-provoking application of linear programming is seen in the research work done by Mamat *et al* (2011) in which they developed a model which incorporated fuzzy numbers to address fluctuating food prices by considering maximum and minimum price levels of food items. The resultant program was able to effectively develop low cost and healthy diets. According to the research work, while linear programming and its related extensions are extensively used to solve diet and health related problems, the application of these models is increasingly being combined with alternative technologies like machine intelligence. In another work, Giarratano and Riley (2005) stated that expert systems use expert knowledge and inference procedures to solve problems that need advanced human expertise.

L. Linear programming (LP) has also been applied in finding solutions to animal rationing problems as used by Aldeseit *et al* (2012). The researchers constructed an LP model which effectively created a least-cost fodder ration combination with the aim of optimizing the fattening of calves at different age stages. According to the research work; with the ever-increasing rate at which technology develops, it is only natural that linear programming models be applied in computerized systems. Examples of such systems that have been created for diet or health-related issues include the work of Bassham *et al* (1984) which assisted dieticians working in hospitals to analyze the diets of patients. Soden and Fletcher (1992) developed a software system that was capable of modifying an existing diet to conform to the nutritional requirements of a certain person. Cadenas *et al* (2004) designed and developed a computer software system which they called SACRA that could be applied to develop accurate feed-mixes for livestock in Argentina while taking into consideration the fact that all animals did not consume similar daily amounts of feed.

3.0 Materials and Methods

In the cause of the design and implementation of an android-based smart nutritionist, the following materials were used to develop the software for an effective and efficient operation of the new system: Android OS, XML and Java, Android Studio, Smartphone, and a laptop**.**

3.1 Efficient Data Management for User Details Activity Based on Bmi Calculation

The method adopted for the development of the android-based smart nutritionist is the waterfall development model. This methodology supports the ease of efficient data management with respect to users' detailed activities. Thereby focusing on how data is fed into the system for processing. User's data are captured through the user interface of the android application as shown in Figure 1. It shows the input design of user details activity of the smart nutritionist. These inputs are gotten using android UI components such as EditText, Spinners, and Buttons. In android, activity refers to a single graphical user interface or screen.

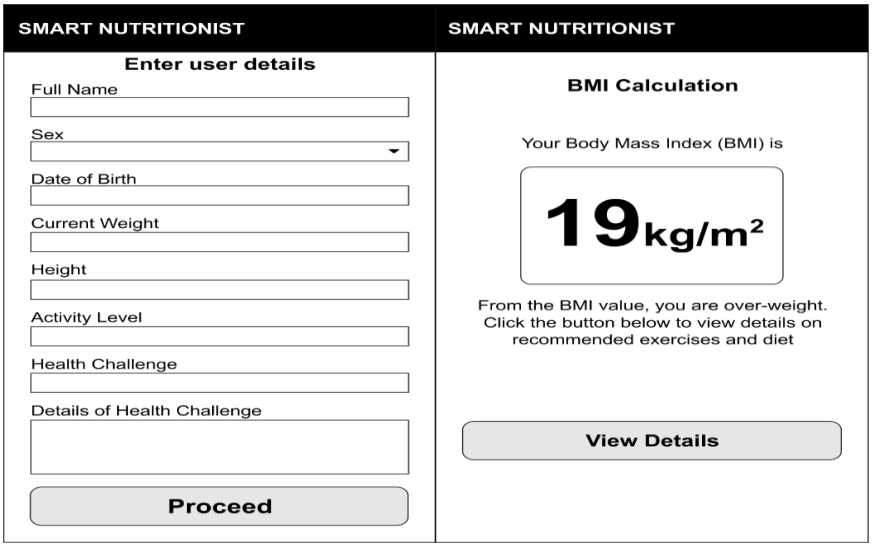

Figure 1: ***Data Management for User Details Activity Based on BMI Calculation***

On the other hand, the results of processing data are displayed to the user. Outputs are presented through the user interface of the android application using android widgets such as TextView, ImageView, Toast and AlertDialog.

3.2 Diet Recommendation and Consultation

The system is an android-based software application developed for smartphones specifically for the purpose of diet recommendation and consultation. It acts as a diet consultant similar to a real dietitian. As shown in Figure 2, a person in order to know his/her diet plan needs to provide certain information to the dietitian such as his/her body type, weight, height, and his/her working hour details. The system asks for all this data from the user and processes it to provide the diet plan to the user. From user-supplied details, the system calculates the Body Mass Index (BMI) and Estimated Energy Requirement (EER) of the individual. Thus, the user does not need to visit any dietitian which saves time and the user can get the required diet plan in just a click. The system can create a meal plan according to a person's lifestyle and particular health needs. The expert system recommends eating a wide variety of healthy and nutritious food.

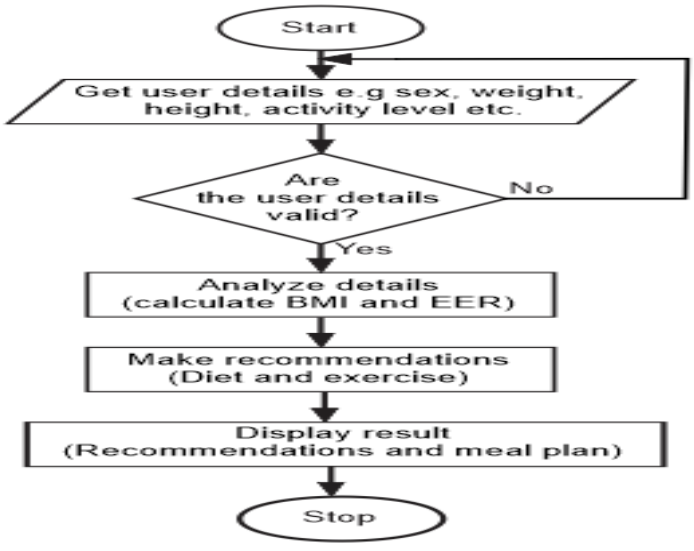

Figure 2: Flowchart of the System

4.0 Result and Discussion

After debugging the codes and testing the application several times, its requirements were effectively and efficiently met as a Graphical User Interface (GUI) using Extensible Markup Language (XML) for data collection from users; other human interactions were successfully developed, accessed with Android OS, Java, and *infinixX624 for* further analysis to be carried out.

4.1 A.B.S.N Graphical User Interface (GUI)

The user interface of A.B.S.N was designed with simplicity and uses familiar icons to enable the users to understand the functionalities of the application, and also the navigation of the system. Provision for customer care support was made to help in-case the user encounters any problems. The code was written to follow the expert system model and is limited to making diet recommendations based on users' responses to questions asked by the system. The features of the system include a dynamic database system that acts as the knowledge base and a complete model of an expert system to portray sample analysis. The knowledge base is achieved using SQLite; this knowledge base can be updated from a user interface meant for this purpose. The graphical user interfaces are divided into pages, namely:

4.2 Initialization Page

To get started with the system, click on the 'GET STARTED' button that is located at the button of the screen. This will launch the application screen where the user is expected to enter his/her details to get some diet recommendations as shown in Figure 3.

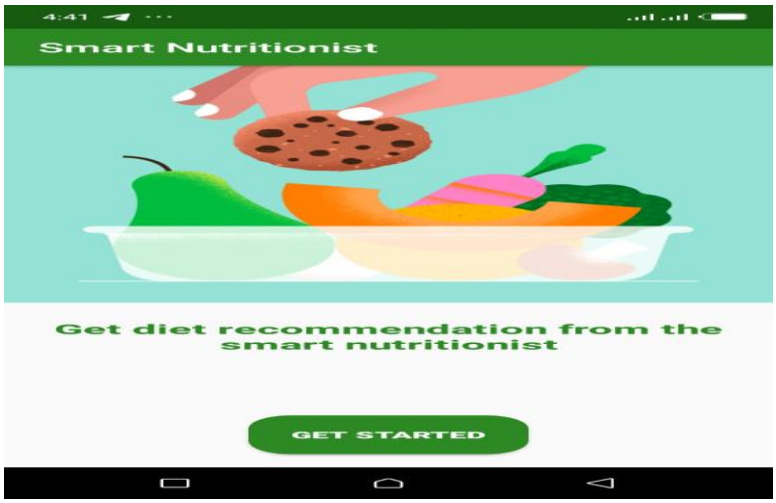

Figure 3: Diet Recommendation Home Page

4.3 User Credential Page

A user is expected to enter some information as such his/her name, sex, age, current weight in kilograms (KG), current height in meters (m), and activity level. There are four options for the activity level which include sedentary, low active, active, and very active. After entering the details, the user can proceed by clicking on the PROCEED button. Figure 4 shows a screenshot showing details of a user who has supplied the required information.

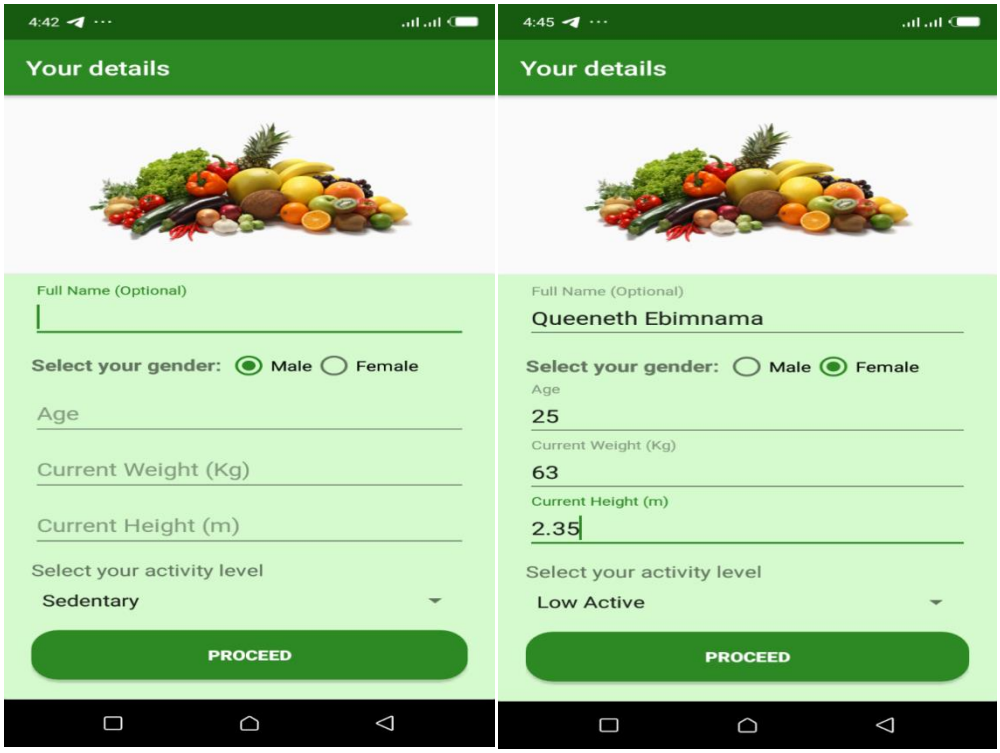

Figure 4: Diet Recommendation Home Page

4.4 Calculating the Body Mass Index (BMI)

When the user proceeds, the system first computes the Body Mass Index (BMI) based on the equation:

$$BMI = \frac{weight}{height^2} \quad (1)$$

By calculating the BMI, the system concludes about the user's "body type": whether the person is underweight, normal weight, overweight or obese. Depending on the user's sex, age, activity level, weight, and height, the system also computes the Estimated Energy Requirement (EER) using the mathematical equations shown below:

For female:

$$EER = 325 - (6.91 * age) + (activity\ level * 9.36 * weight) + (726 * height) \quad (2)$$

For male:

$$EER = 662 - (9.53 * age) + (activity\ level * 15.91 * weight) + (539.6 * height) \quad (3)$$

Consequently, based on the concluded body type and Estimated Energy Requirement (EER), the expert system then makes diet recommendations. The BMI and EER result is also presented as audio output via the phone's speakers. Typical values of BMI and EER are shown in Figure 5.

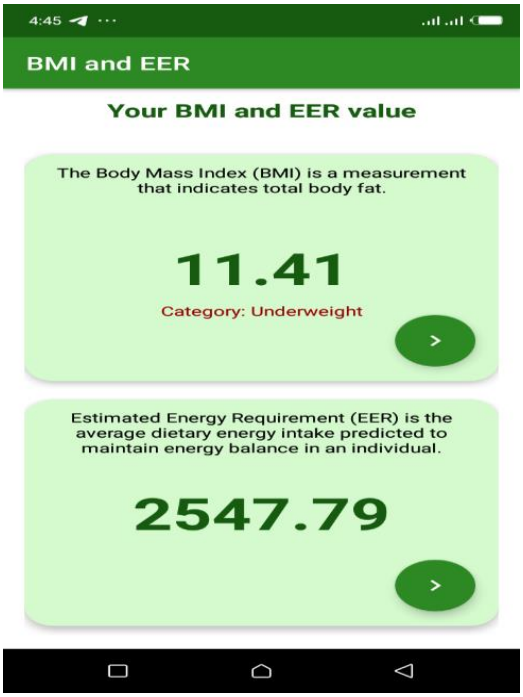

Figure 5: Values of BMI and EER

4.5 BMI Charts

Depending on the value of BMI (body type), the user can get tips on how to gain or lose weight. If the user is under weight, he/she will get information on how to gain weight otherwise, information on how to lose weight is presented to the user as shown in Figure 6.

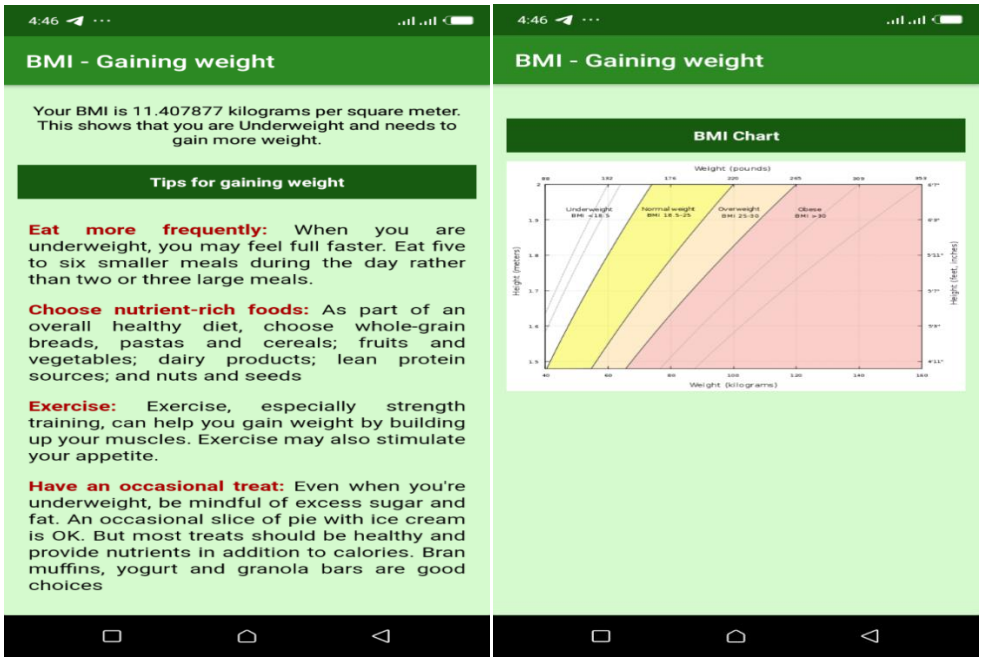

Figure 6: Chart showing Relation between BMI, EER and Weight

4.6 Diet Recommendation

In the screenshot shown in Figure 5, clicking on the forward arrow in the Estimated Energy Requirement (EER) section launches the screen where diet is recommended to the user as shown in Figure 7. This recommendation is made based on the BMI and EER as shown in equation 1, 2 and 3, respectively.

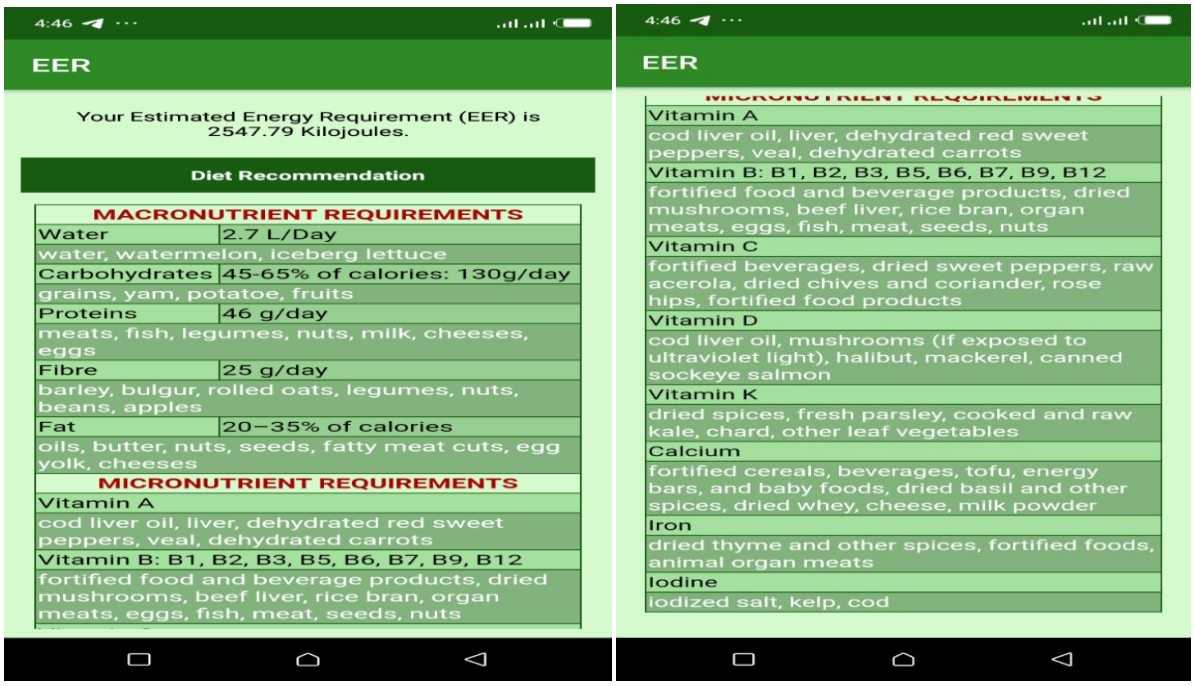

Figure 7: Micronutrient Requirement

5.0 Conclusion

An android-based smart nutritionist has been developed using Android OS, XML, Java, Android Studio and an infinixX624B and implemented using waterfall development model. The prototype system provides expertise in diet recommendation and offers a wide range of advices about the quantity of various nutrients that may meet the basic needs of the body; such as proteins, vitamins, fibers, and minerals. The system helps the user to decide, to increase or decrease their weight by knowing their body type. Moreover, the system also provides the user with meal plans and the food they need to consume for their body type. The use of expert systems can improve people's awareness and help them get proper advice on a healthy diet. Providing an expert system for diet and nutrition adds value to people's life especially in developing countries. With the advancement in technology, software's are being developed; machines are being taught to learn so as to do more complex jobs. The system could be configured for use in large hospitals and even in eateries because of its enormous benefits to health. The developed system is easily extensible and can be improved by adding more features to it. Also, a subsystem that can enable the interaction between patient and dietitian through video calling and secure prescription can be integrated.

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