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WEB-BASED DECISION SUPPORT SYSTEM FOR DIETARY MEAL PLAN RECOMMENDATION

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ABSTRACT

Due to socioeconomic changes, many people in both developed and developing countries are struggling with overweight and obesity as a result of sedentary lifestyle and unhealthy dietary habits. Preventive strategies need to be established to promote awareness on balanced diet and active lifestyle to improve overall health population. Attempts in health care services to provide the guidance for decision making in nutrition counseling have been done through the development of web-based decision support systems. Although these decision tools prove to be helpful in promoting suitable changes to the eating habits among overweight and obesity people as part of their health treatments, the tools are lacking to focus on preventive strategies especially among healthy people to cultivate the healthy lifestyle habits. This include to provide personalized menu plans that consider and suit users diversity requirements and their body needs. Therefore, objective of this study is to design and develop a web-based decision support system for recommending dietary meal plan based on the Daily Calorie Requirement (DCR) and daily activity level, known as eDietForYou. This tool could assist people to achieve their ideal weight in the way as recommended by dietitian. All of the calculations and decisions are suggested automatically by the system. Hence, this system is robust and reliable as there is no human error.

Keywords: *Daily Calorie Requirement, Meal Plan, Web-based Decision Support System, Recommendation*

1. INTRODUCTION

Nowadays, due to socioeconomic changes, many people in both developed and developing countries are struggling with overweight and obesity as a result of sedentary lifestyle and unhealthy dietary habits. According to the statistics, the prevalence of obesity in developed country such as United States has escalated significantly since 1980 and the percentage continues to growth [1]. Meanwhile, with increasing numbers of Malaysians that have become overweight and obese over recent years, Malaysia is a developing country that now the most overweight and obese nation in the South East Asia region [2][3][4].

Overweight and obesity are significantly associated with an increased risk of non-communicable diseases such as type 2 diabetes, hypertension, stroke, asthma, arthritis, and poor health status, that could diminish the ability to have a better quality life. It is a critical public health issues that has received substantial concerns in societies around the world [5]. Despite of socioeconomic changes, lack of nutritional awareness and healthy lifestyle education are potentially associated with increased risk of overweight and obesity [6][7].

Governments and NGOs need to establish preventive strategies to promote awareness on balanced diet and active lifestyle in order to improve overall health population through ubiquitous health care services [8]. Accordingly, such health care services are required to make nutritional information more accessible, effective and efficiently distributed through the use of information and communication technology so that these systems can support people in managing healthier daily routines. The development of web-based decision support tools could assist people with providing the guidance for decision making in nutrition counseling. Several decision support tools such as a web-based school meal planning system [9], food recommender system [10] and knowledge-based dietary nutrition recommendation [11] prove to be helpful in obesity management. However, promoting suitable changes to the eating habits is not only crucial among overweight and obese people but also for healthy people as one of the prevention strategies in cultivating the healthy lifestyle habits. In addition such tools are unable to

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provide personalized menu plans that consider and suit users diversity requirements of their body need such as Daily Calorie Requirement (DCR) and dietary preferences. Planning a healthy and nutritious meal plan is a complex task if an individual does not have sufficient knowledge and lack the skill or ability to translate the knowledge into practice, thus brought the challenge to dietician [12]. Besides, meal planning can be time-consuming and frustrating if an individual just simply plans without having an adequate knowledge about nutrition and appropriate diet, especially for the individual who is lacking in motivational readiness.

In this paper, a web-based decision support system, known as eDietForYou is designed and developed for recommending dietary meal plan based on DCR and daily activity level. The decision support system herein include not only static dietary nutritional data but also personalized diet menus based on individuals specific goal and their body needs. Also through the use of web-based technology, the personalized menu can be retrieved any type of users who intend to obtain nutrition guidance. Thus, the research hypothesis is the proper design and development of web-based decision supported system for planning dietary meal could improve awareness towards healthy lifestyle among people.

The rest of the paper is organized as follows. First, the Related Works section presents the state-of-the-art of web-based decision support systems for recommending dietary meal plan. Meanwhile, the subsequent section outlines the overall framework of the research methodology. The proposed architecture of eDietForYou is discussed next and followed by the implementation of the prototype. Finally, the last section concludes with a summary of this paper and future research directions.

2. RELATED WORK

The goal of public health care is to maintain and improve overall health population. With the information and scientific technologies advancement, health care systems either static web-based information system or decision support system have evolved considerably over the past years. As the paradigm of health management has shifted to preventive management [11], health care systems are reviewed in this section.

2.1 Web-based Information System

Table 1 shows the comparison of several well-known web-based information system such as MyPlate [13], Malaysian Food Calorie Guide [14] and MyFitnessPal [15]. Based on the studies, the comparison has been carried out to look at the system functionalities such as the availability of nutritional and fitness data, searchable food database, Body Mass Index (BMI) analysis, and meal plan recommendation based on DCR & physical activity level.

Table 1: Comparison of Web-Based Information Systems

Criteria \ System	MyPlate [13]	Malaysian Food Calorie Guide [14]	MyFitnessPal [15]
Static nutritional and fitness data	Yes	Yes	Yes
Searchable food database	No	Yes	Yes
BMI analysis	Yes	No	Yes
Meal plan recommendation	No	No	No

MyPlate [13] is an online meal planner tool managed by United States Department of Agriculture. The main focus of the system is to provide a convenient and informative source on how to eat right and live well such as giving diet, cooking and exercising tips to the user. Besides, the system also provides BMI analysis. However, the system did not provide meal plan recommendation.

Malaysian Food Calorie Guide [14] serves as reference website for health, nutrition and fitness information. People is allowed to access tips and information on nutritional and fitness on the system. Other than that, the system also provides free searchable database engine for Malaysian food calorie. In addition, the system also allows people create their own meal plan manually and share the meal plan with others. However, the system did not provide any functionalities to analyze Body Mass Index (BMI) and automated meal plan recommendation.

MyFitnessPal [15] has been known as a calorie counter web-based information system as the main function of the system is to track the diet progression of an individual. First, the user is required to create an account for the personalized diet and exercise profile. Based on the personalized data, Daily Calorie Requirement (DCR) is calculated so that they can achieve their goal to either to maintain weight, gain weight or lose weight. In order to keep track the progress, user

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needs to manually add every meals that they consume daily by using the provided food database. The searching of food from the food database provides food's information such as calories, serving size and nutrition facts.

2.2 Web-based Decision Support System in Healthcare Services

With the increasing use of internet technology, web-based decision support system has been extensively researched as a decision support tool to provide accessibility to specialized healthcare assistance. This including studies in automatic diet prescription and monitoring for patient based on medical prescriptions and nutritional needs [16][17]. Besides, web-based decision support system also has been studied to assist in managing eating habits among obese people by providing proper recommendation of dietary meal plan [10][11]. However, these systems merely focused on managing diabetics patients care. The web-based decision support system is not only benefit to provide a preliminary analysis to support people when they are having problems in health, but the decision tool also should be able to monitor healthy eating and physical activity practices among healthy people for fostering healthy lifestyle habits.

Meanwhile, decision support tools for recommending nutritious recipe and menu based on users dietary preferences such as ratings and feedbacks [18][19][20] and previous recipe selections [21] have been successfully developed. The recommender systems should not only be able to suggest nutritious menu but also should be able to consider users daily activity level and calories requirements.

3. THE DESIGN ARCHITECTURE

This section discusses the design architecture of web-based decision support system for dietary meal plan recommendation or eDietForYou. The architecture as shown in Figure 1 is composed of multi layers and these layers are described as the presentation layer, the application layer and the data layer.

Web browser is primarily concerned with presentation layer. The layer represents web-based user interface where it serves to manage the interaction between users to the application. It is the gateway to the application layer to interact with the data layer to make requests and also to retrieve data from the data layer. It then displays to the user the data retrieved from the application layer. The web-based user interface of eDietForYou is created by using bootstrap, Hypertext Markup Language Version 5 (HTML5), JavaScript, JavaServer Pages (JSP) and Cascading Style Sheets (CSS) elements.

Web servers are described within the application layer. The layer technically processes inputs received by the presentation layer as it plays the role of interaction with the database layer. It also coordinates business logics of eDietForYou and processes commands. This layer encompasses several main tasks that can be performed by registered users such as user's authentication, profile management, food database management and statistical analysis.

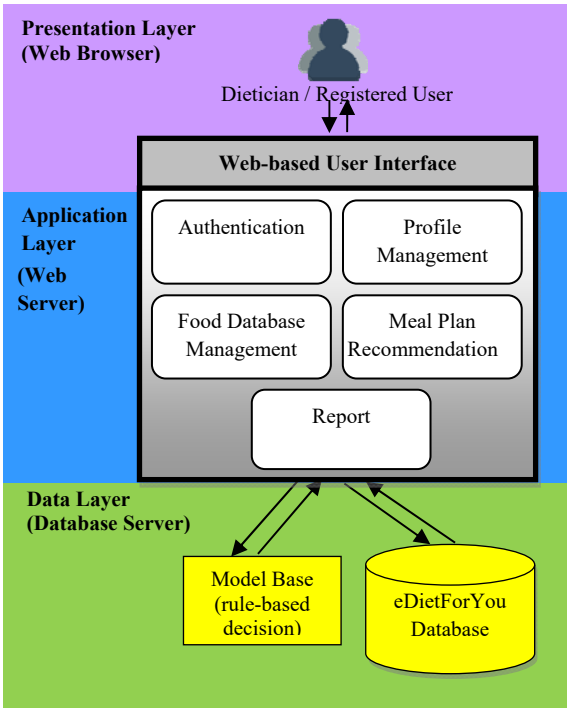

Figure 1: The Architecture of eDietForYou

Meanwhile, the database server and model base reside within the data layer. The layer stores data pertaining to the eDietForYou application. It consists of a relational database management system to save all the data and also includes the model base (rule-based decision) to formulate dietary meal plan recommendation based on information provided by users. Figure 2 illustrates the logical structure of eDietForYou database using entity-relationship diagram. It consists of eight normalized tables which are login, user, userdietaryinfo, dietician, food, foodmedical, mealtime, and nutritionfacts.

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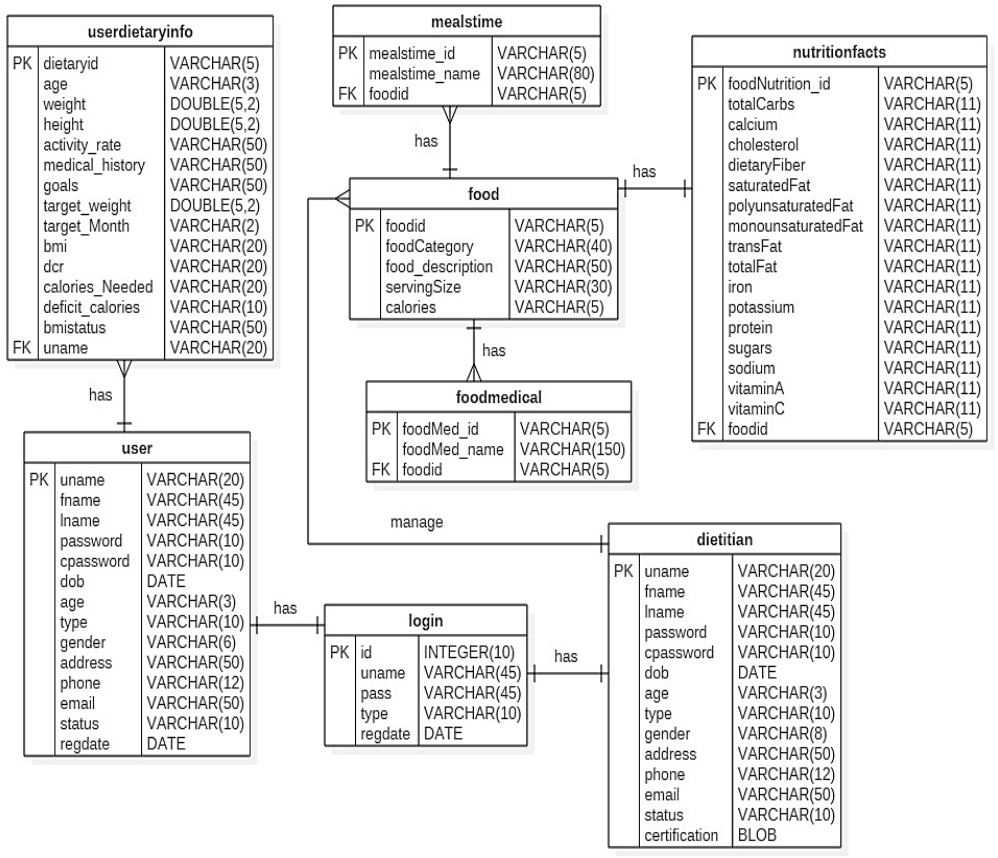

Figure 2: Entity-Relationship Diagram of eDietForYou Database

4. THE DEVELOPMENT OF WEB-BASED DECISION SUPPORT SYSTEM FOR DIETARY MEAL PLAN RECOMMENDATION

This section explains set of functionalities provided in eDietForYou. Users of this system are categorized into general users and dietitians. General users can be grouped into registered user and unregistered user. The difference between registered and unregistered users are described in terms of functionalities that can be accessed. Unregistered users is limited to check their BMI analysis and DCR. If they wish to access other features including the dietary meal plan recommendation, they need to register to the system. Meanwhile, dietitian is a certified expert on diet and nutrition who is allowed to manage the information on food and its nutrition facts. The overall interactions users and the system is described in the Figure 3.

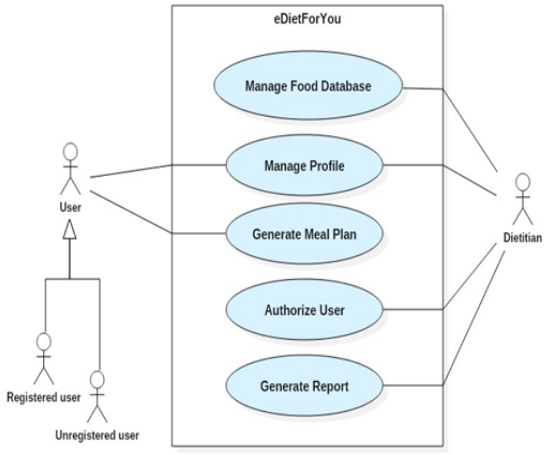

Figure 3: Use Case Diagram of eDietForYou

4.1 Authentication Module

Authentication module requires unregistered users to sign up the system before they are allowed to use other functionalities of the system. Figure 3 shows the interface of user registration. To register

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an account, user needs to fill in the information required such as user name, first name, last name, password, date of birth and age. Then, the registered user needs to log into the account through the login page as depicted in Figure 4.

A personalized dashboard as illustrated in Figure 5 is displayed after an authorized user has successfully logged into the system. It acts as an intermediary for the user to navigate to other different functionalities. The tabs indicate the main menu's option for home, profile, and health calculator and meal plan sections.

Meanwhile, Figure 6 shows the authentication module for dietitian. This process is conducted by the appointed admin which is also a certified dietitian. Admin is able to view list of registered dietitians and authorize the dietitians before they are allowed to use other features in the application. Authorization of dietitian is essential in order to ensure only certified and eligible dietitian is given an access to manage food database. Figure 7 depicts the interface for verifying dietitian based on supporting certificate attached.

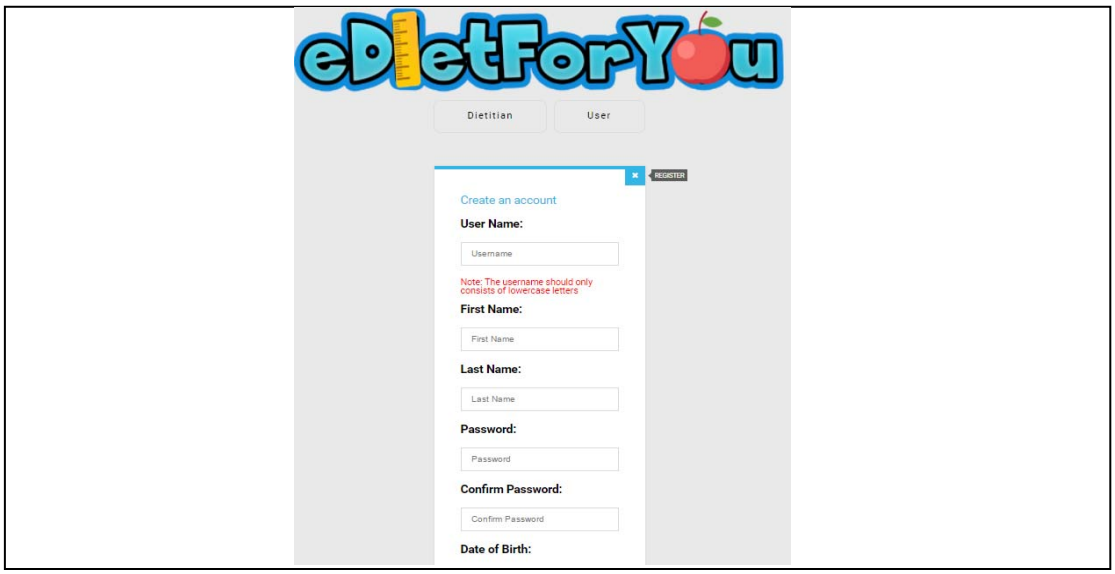

Figure 3:User Registration Interface

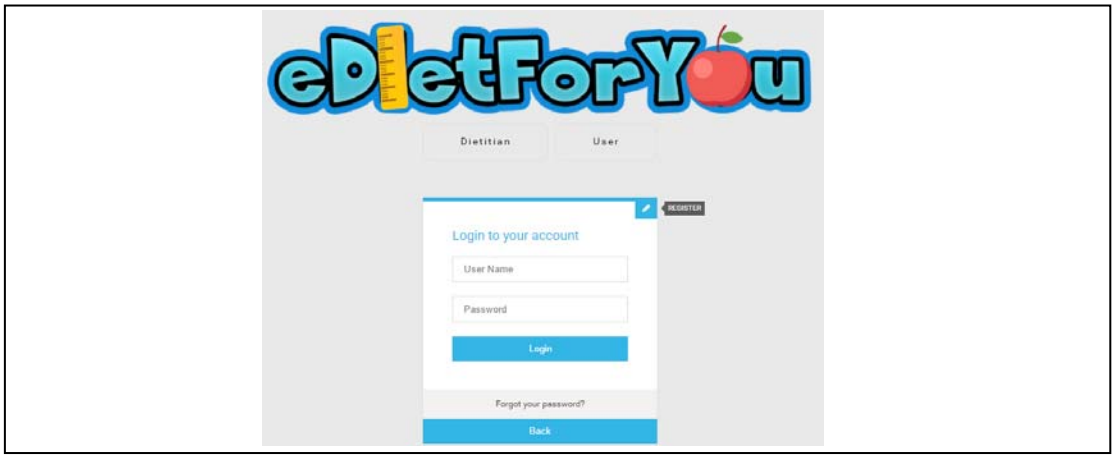

Figure 4: User Login Interface

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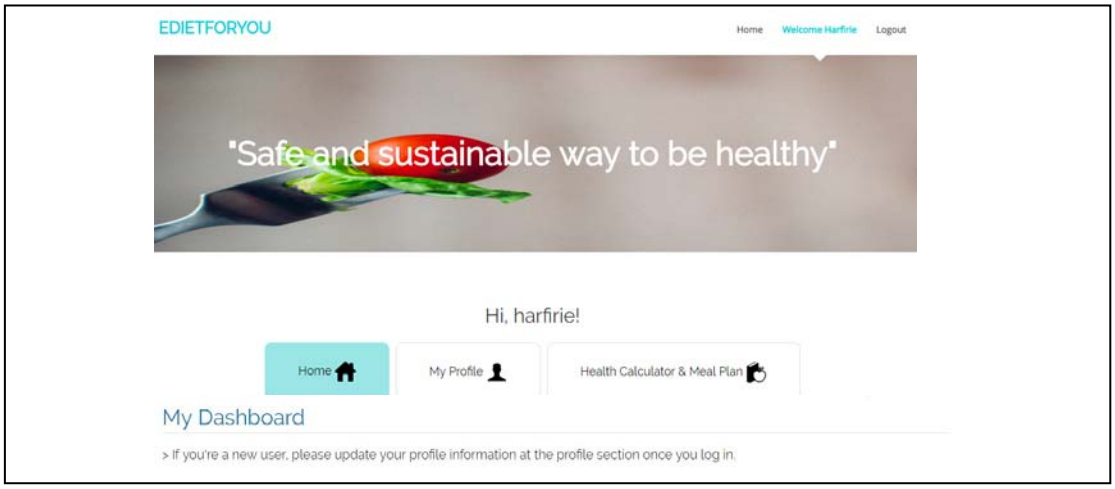

Figure 5: Personalized Dashboard

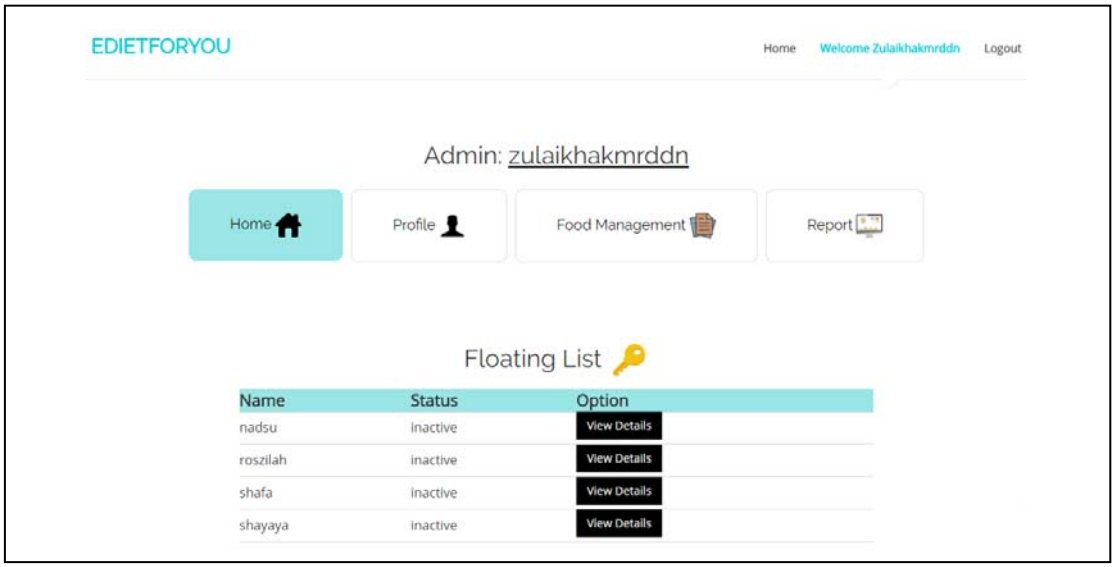

Figure 6: Dietitian Authorization Interface

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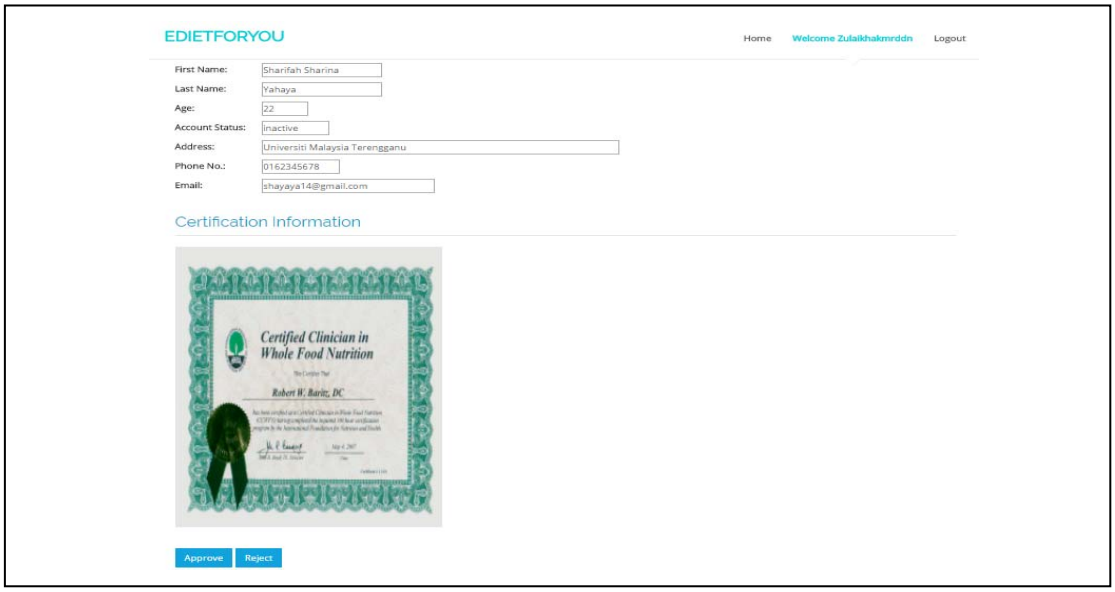

Figure 7: Dietitian Verification Status Interface

4.2 Profile Management Module

Another feature of eDietForYou is profile management module. This function allows the newly registered user to update their profile information. The user profile is categorized into personal information and dietary information. Personal Information as shown in Figure 8 consists of information such as first name, last name, date of birth, age, gender, address, phone and email. The user can view and update their personal information in this section.

Meanwhile, Figure 9 shows the user profile interface for dietary information section. The dietary information section enables the users to view and update the their physical details, daily activity level, medical details, and target and goals. These information is useful for recommending personalized meal plan.

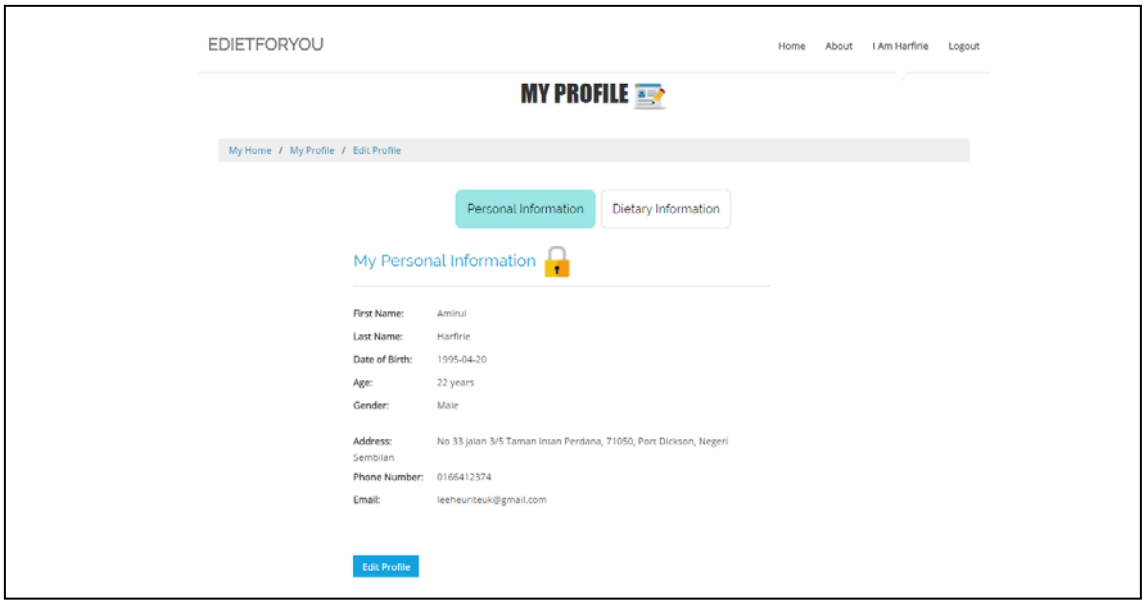

Figure 8: User Personal Information Interface

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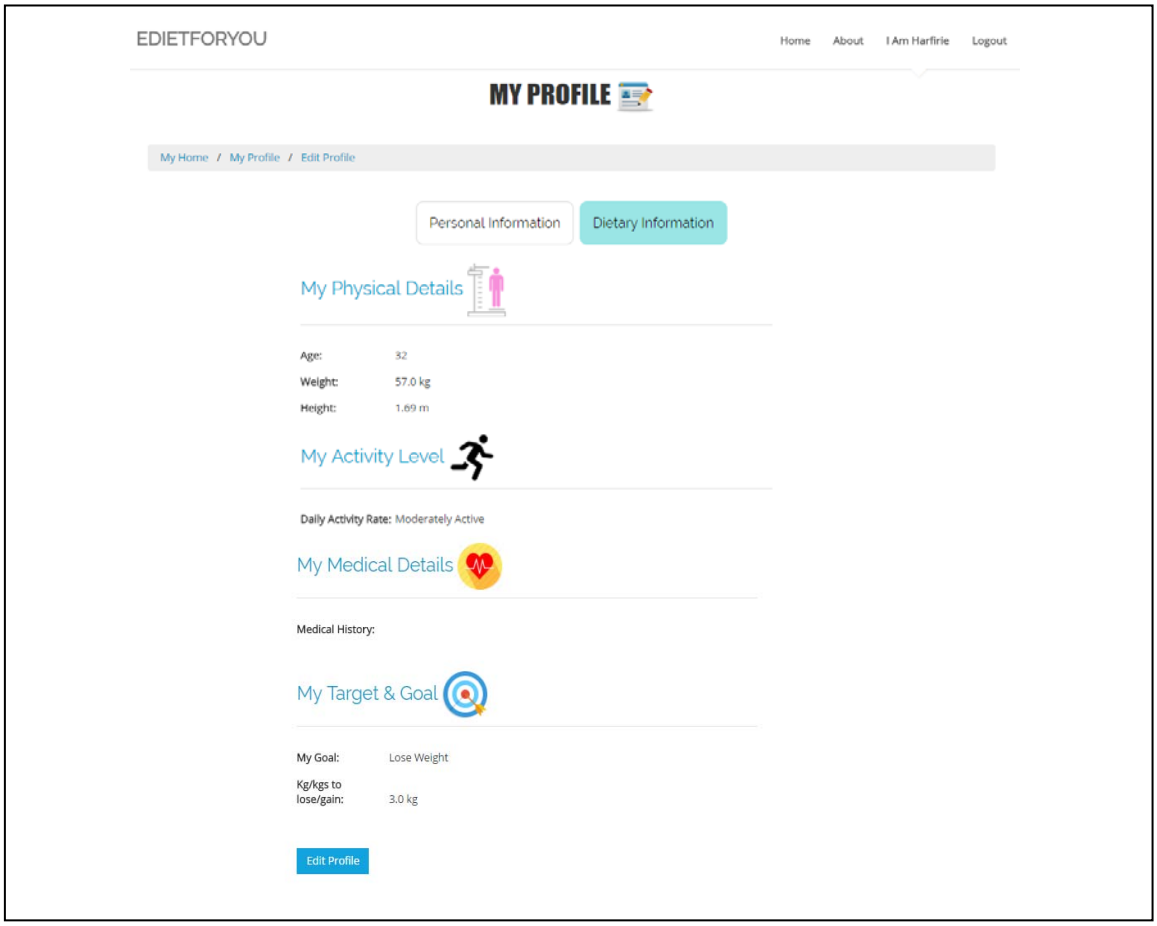

Figure 9: User Dietary Information Interface

4.3 Meal Plan Recommendation Module

Meal plan recommendation module is a core feature in eDietForYou. It works based on the users' profile and dietary data and food database. Before a suitable dietary meal plan is recommended, the application provides a preliminary analysis on the Body Mass Index (BMI) and DCR as depicted in Figure 10. The analysis result is useful for the application to recommend suitable meal plan. Figure 11 illustrates the meal plan recommendation interface. The meal plan suggests three different types of food for each meal including the calories and portion of each meal. The user can print the meal plan if they want to.

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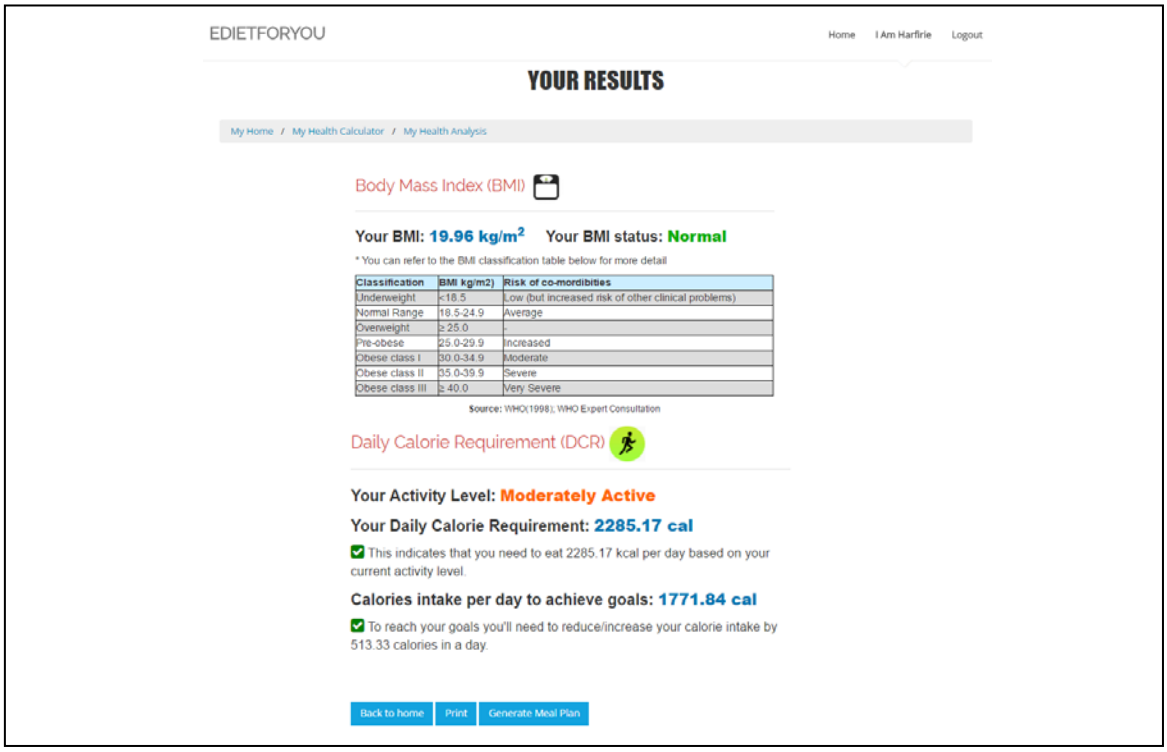

Figure 10: BMI and DCR Analysis

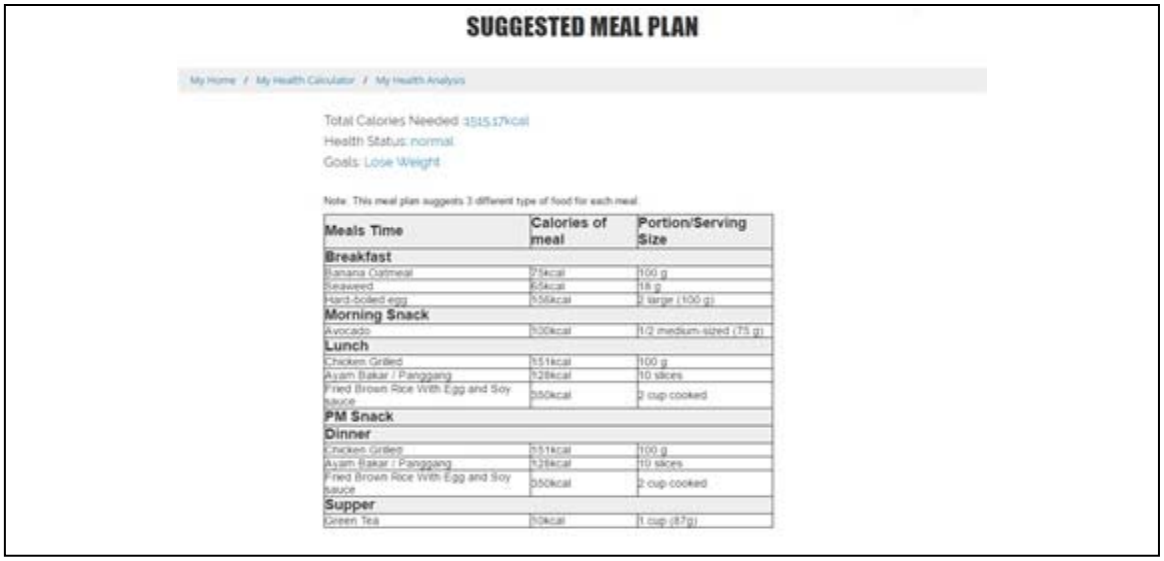

Figure 11: Meal Plan Recommendation Interface

4.4 Food Database Management Module

Food database management module is available for certified dietitians to manage information on food nutrition. As represented in Figure 12 and Figure 13, food information contains data about its serving size, calories and nutrition facts details. In this module, the dietitian is given an authorization to add new food information, edit the existing food information and search.

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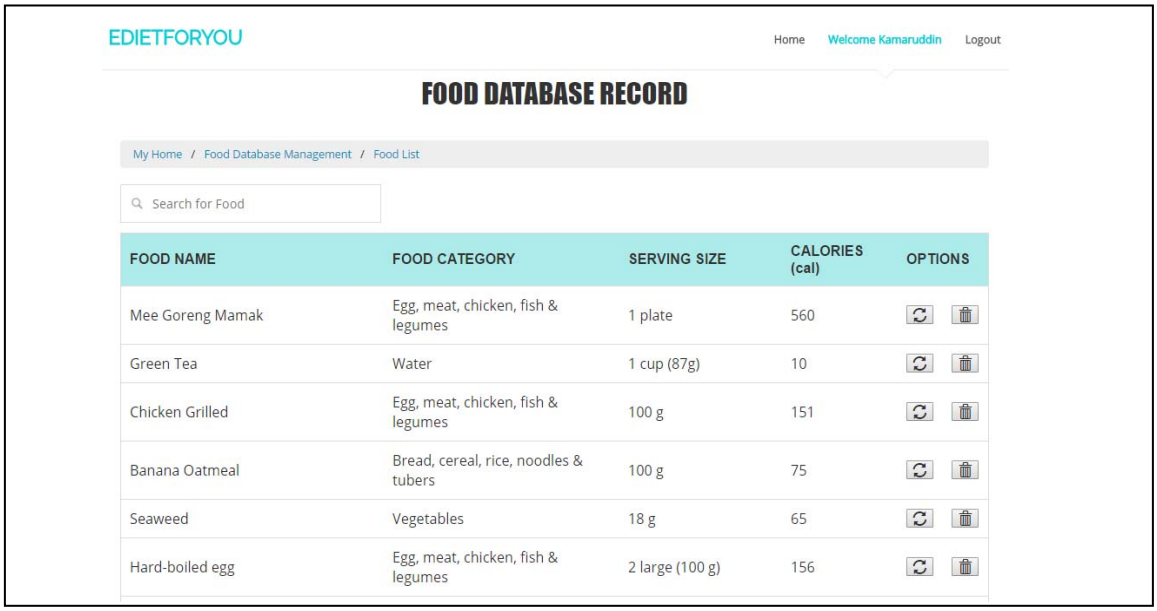

Figure 12: Food Database Interface

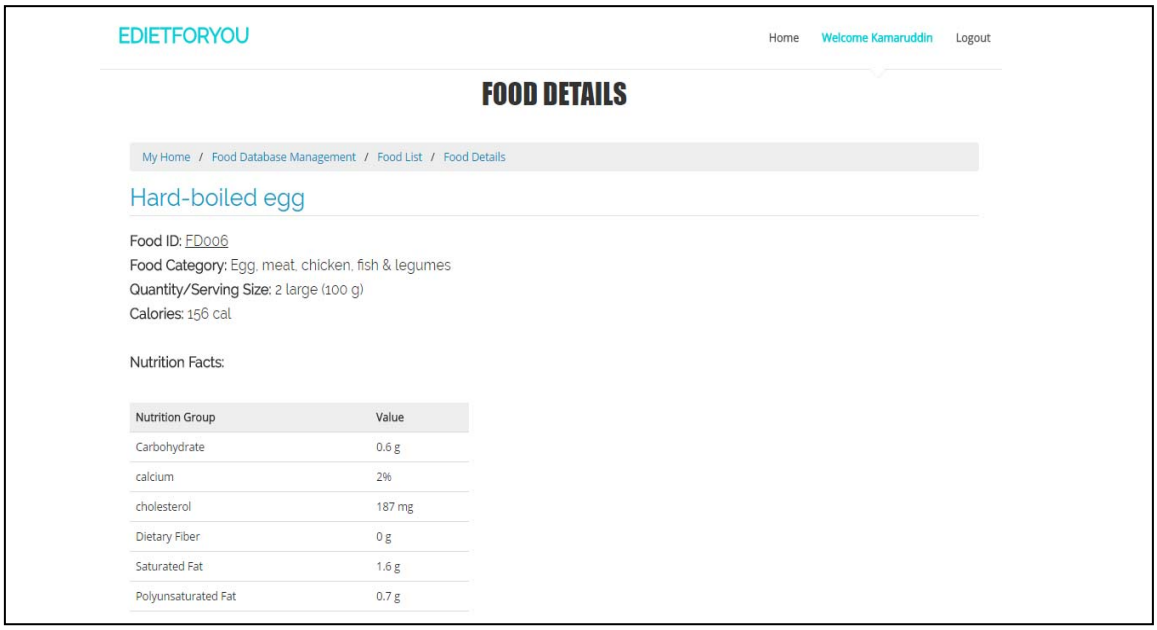

Figure 13: Food Nutrition Facts Interface

4.5 Report Module

Report module allows dietitian to monitor yearly statistical data about the distribution of registered users based on their BMI level. The snapshot of yearly report interface is portrayed in Figure 14.

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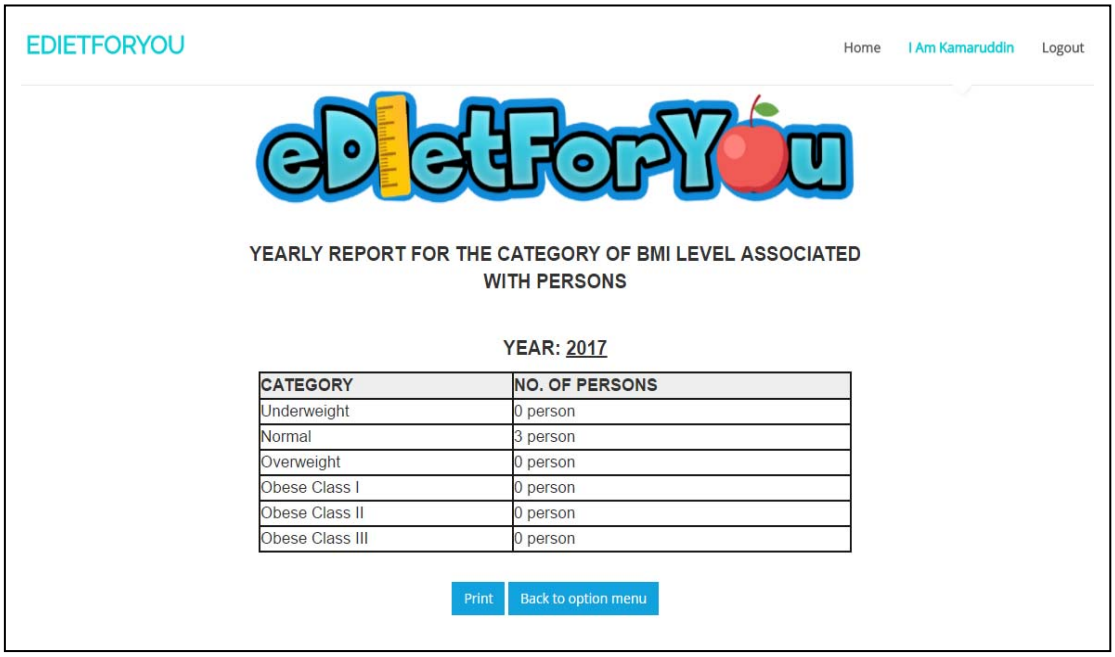

Figure 14: Yearly Report Interface

5 DISCUSSION AND CONCLUSION

The application of eDietForYou has contributed as an useful tool to assist and guide people to achieve healthy diet. This system is also expected to assist the Ministry of Health of Malaysia to create awareness and inculcate healthy lifestyle practice amongst the community as it guides people on getting the right meal plan that suits the needs of their body. Besides, the eDietForYou is different compared to other meal plan system because it generates meal plan based on user's Daily Calorie Requirement (DCR) and medical history.

For the future works, the application of eDietForYou could be improved by adding a new platform for communication purpose by creating an online forum which allow the user to communicate with the dietitian. Besides, the user can also share their knowledge and opinion with other users who share the same interest as them. Another future research direction is to include the user progress module. Adding the function of diet tracking where the user can log their daily meal. This function is useful as the user will be aware of their optimum calorie intake in a day. Diet tracking can also motivate the user and give better results. In addition, the application also can be improved by providing the fitness suggestion to the user according to their interest and ability. For example, giving a variety of fitness choice such as Zumba, home workout, yoga and jogging.

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