

Building an Advisory System for Nutrition of Pregnant Woman

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ABSTRACT

The present paper aims to build an advisory system for calculating the daily nutrients requirements of proteins, fats, and carbohydrates calories for pregnant women. It deals with adults and adolescent pregnant women. In addition to the pregnant woman who suffers from some health problems such as Hypertension, Diabetes, Anemia and Coronary heart disease. The daily nutrients requirements mainly depend on health status, weight, height, age, pregnancy stage, socioeconomic status, food preferences, and physical activity. The nutrition needs will be distributed on daily meals using the food exchange system common among Egyptians. Accordingly, this work developed a system that helps pregnant women to choose daily meals according to their nutritional needs. Also, this system helps the fetus to get nutrients that ensure his safety birth. Moreover, it saves time to go to a nutritionist and it presents nutritional advice for pregnant women depending on their health status.

Keywords: Pregnancy, Calories, Daily Nutrients Requirements, Food Exchange System, Clinical Decision Support System, Advisory System.

I. INTRODUCTION

Pregnancy is a stage in a woman's life in which one or many off springs develop inside her. The duration of gestation varies between 38 to 40 weeks [1]. Eating a healthy diet during pregnancy is essential in both preventing congenital disabilities and supplying the fetus with requirements from nutrients to grow and develop his organs [2]. Pregnant women must have daily optimal energy needs for their health, but most of them don't take suitable calories because they usually do not know how to calculate the food calories they want to eat [3]. A healthy diet is a diet that provides pregnant women with the right combination of energy and nutrients. The characteristics of a healthy diet are varied, adequate, and balanced [4]. A well-balanced diet that contains a variety of foods provides the body with a range of different nutrients [5]. The food exchange system is an easy way to make a balanced food, and this system depends on putting similar foods together in a group. In each group, foods have about the same amount of protein, fat, carbohydrate, and calories [6]. The food exchange system is

beneficial for the nutritionists to put traditional dishes in meal plans.

Advisory system is a kind of expert systems which automatically supports decision-making for decision makers. Advisory system only helps in decision making process and leaves the final decision making authority up to the decision makers [7]. It is used in many fields such as health, law, aviation systems, agriculture, commerce, industry, and many more [8-11]. Clinical Decision Support System (CDSS) is an important area of health information technology. It is developed to help clinicians and other healthcare professionals in diagnosis and decision-making. CDSS uses healthcare data and the patient's medical history to give advice [12]. Applying advisory systems in health domain is considered an example of CDSS.

This paper aims to provide a smart nutrition advisory system to help pregnant women for getting integrated health nutrition to support her and her fetal health. The proposed system calculates the calories and the nutrients requirements of the pregnant woman and

distribute them on the daily meals. It is interested in a pregnant woman, either adult or adolescent. Also, either normal or suffering from some healthy diseases, such as: (Hypertension - Diabetes - Anemia and Coronary heart disease).

The importance of this system comes from pregnant women can use it themselves at home with step by step guidance process. Also, it helps them to choose their daily meals according to their food preferences and socio-economic status. Besides, it saves time and money instead of visiting the nutritionist. Moreover, the system provides advice about healthy foods they have to eat according to their health status.

II. RELATED WORK

Some systems have developed for dealing with nutrients needs. Fuzzy ontology, rule-based reasoning, artificial bee colony algorithm, and genetic algorithm had proposed for suggesting nutrients diet and recipes based on the recommended diet plan by Madhu Raut *et al.* [13]. Case-Based Reasoning (CBR) had used for diet menu planning by Rajendra Akerkar [14]. A knowledge-based hybrid decision model for nutrition management that uses neural networks had proposed by Joo-Chang Kim *et al.* [15]. An expert system had created to solve multiple faces of the diet problem using multi-objective linear programming models by Annette van der Merwe *et al.* [16]. An expert system prototype on nutrition and diet domain had developed using a rules-based system technique by Balees *et al.* [17]. However, there are a few systems that had developed for pregnant women's nutrition. Fuzzy expert system, that contains some functions such as nutrition advice, calculation of ideal weight, benefits of several nutrients, and calorie evaluation of some daily activities had proposed by Okan [18]. Fuzzy logic had used to model

information inconsistency in food calorie and assessing daily calorie needs by Restu *et al.* [3].

III. ADVISORY SYSTEM

Advisory systems are systems that provide advice and help to solve problems that are usually solved by human experts; so such, advisory systems can be classified as a kind of expert system [19]. Advisory system works in collaboration with a human decision maker, who takes the final decision. Thus, the main goal of an advisory system is to collect knowledge from human experts. Then, coding it into a shape that can be used by a computer to present alternative solutions to similar problems in this domain of expertise [20]. Therefore, the possibility of producing a positive outcome is maximizing and the degree of risk is minimizing. For building any advisory system there are three main processes to take. These processes are knowledge acquisition, cognition, and interface. The first step collects information and knowledge about the problem of study. The second step defines the problem through the identifying of environmental variables. The third step allows users to access the system through multiple windows.

IV. PREGNANCY NUTRITION

Pregnancy is the most delicate period in a woman's life. Therefore, she has to get the right healthy diet that can keep her and her fetus safe during that period. Thus, a balanced healthy diet should introduce for her according to her nutrients requirements. These nutrients transform to healthy meals by using food exchange system. These nutrients are explained as follows [21-22]:

A. Proteins' Sources

Proteins can obtain from meat, fish, eggs, legumes, and milk. It forms the structure of each cell of body muscle, tissue, tendons, internal organs, skin, nails, and hair.

B. Carbohydrates' Sources

Carbohydrates are a primary energy source of the body and also vital for nervous systems and brain functions. They can obtain from cereals, bread, pasta, rice, and potatoes. They also exist in fruits, vegetables, grains, and dairy products.

C. Fat's Sources

Fats can provide double energy compared to protein and carbohydrate by weight. It is essential for the transportation of fat-soluble vitamins in the body. It can obtain from cream, nuts, olive, and the oils of cottonseed, corn, soybean, and flax. Table 1 shows examples of nutrients that need special attention during pregnancy.

V. THE PROPOSED SYSTEM DESCRIPTION

The proposed advisory system consists of four essential steps that are followed to obtain the daily calorie needs and distribute it in healthy nutritional meals for pregnant women. These steps are knowledge acquisition from nutrition experts', cognition, user interface and a set of nutritional advice. Fig 1 shows the proposed advisory system architecture for the nutrition of a pregnant woman.

Table 1: Examples of nutrients that need special attention during pregnancy [23-26]

Nutrients	Importance	Good Sources
Calcium	<ul style="list-style-type: none"> - Build strong bones and teeth. - Help in growing a healthy heart, nerves, and muscles for baby. - Develop a normal heart rhythm and blood-clotting abilities. 	<ul style="list-style-type: none"> • Yogurt • Milk • Cheese • Canned fish • Oranges • Dried Figs • Kale • Almonds
Iron	<ul style="list-style-type: none"> - Promote tissue growth, increases blood supply. - Transport of oxygen to the developing fetus. - Protect the health of a pregnant woman. 	<ul style="list-style-type: none"> • Leafy greens • Meats and seafood • Eggs • Beef cereal. • Bread and pasta • Beans and nuts • Beets • Dried fruits
Folic acid	<p>Folic acid was identified as a critical vitamin to prevent neural tube defects in baby, such as spina bifida.</p>	<ul style="list-style-type: none"> • Green leafy • Cooked Beef liver • Legumes • Bread and pasta • Bananas • Nuts and Seeds • Citrus Fruits • Beets • Eggs
Vitamin A	<p>Vitamin A is critical for:</p> <ul style="list-style-type: none"> - Proper cell growth. - The development of the skin, eyes, and blood. - immunity and resistance to infection. 	<ul style="list-style-type: none"> • Herring • Tomato juice • Dried apricots • Cantaloupe melon • Mango • Sweet red pepper • Spinach • Carrots • Sweet potato
Vitamin C	<ul style="list-style-type: none"> - Produce collagen, which supports healthy growth, bone strength, and wound healing. - Support baby with the immune system - Help baby to absorb iron and build up stores. 	<ul style="list-style-type: none"> • Chili Peppers • Guavas • Sweet Yellow Peppers • Thyme, Parsley • Kale • Kiwis • Lemons • Strawberries • Oranges

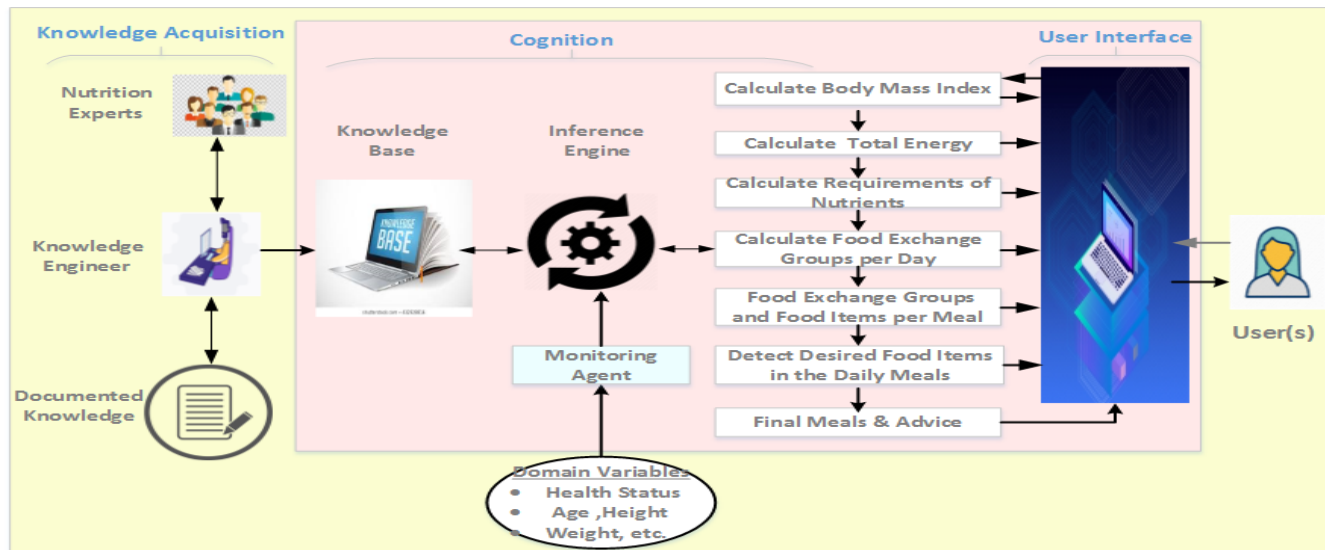


Figure 1: The proposed advisory system architecture for the nutrition of a pregnant woman

The detailed analysis of the proposed advisory system is explained as follows:

A. Knowledge Acquisition

Knowledge acquisition is the process that refers to extract and organize knowledge from domain experts. There are many knowledge acquisition tools that have been developed. In the proposed advisory system, the knowledge was extracted through interviews with a group of nutrition experts. In addition to a reasonable amount of reference materials (books, journals, reports and websites in nutrition domain) which called documented knowledge.

Then, acquired knowledge is converted into a knowledgebase by the knowledge engineer. This knowledgebase will be ready for use which called knowledge representation.

The role of the knowledge base is to simply store domain specific knowledge. This knowledge base can be referenced by the inference engine. This inference engine frames the problem and identifies possible solutions to it. These solutions are presented to the user via the user interface.

B. Cognition

Cognition is the process that refers to monitor environmental variables to determine a solution to the problem. Environmental variables, user input, and the knowledge base are used to evaluate different suggestions to the decision maker. In the proposed advisory system, the cognition process starts with entering health status and personal data by the pregnant woman through the user interface. Then, some different operations are performed on this data. The cognition process can be explained in detail as follows:

– Input Health Status

A pregnant woman determines her health status before and during pregnancy, either healthy or suffering from (hypertension - diabetes - anemia – coronary heart disease). According to her health status, this system presents healthy meals and guidelines for foods to eat, and foods to avoid. Table 2 shows healthy indicators for both normal and patient of pregnant women.

Table 2: Healthy indicators for both normal and patient of pregnant women [27-28]

Disease	Normal	Patient
Anemia	<p>•Hemoglobin (Hb) Range of hemoglobin for pregnant women during:</p> <ul style="list-style-type: none"> - The first trimester (11.6-13.9) grams (g) per deciliter (dl). - The second trimester (9.7-14.8) g/dl - The last trimester (9.5-15) g/dl 	Anemia diagnoses in pregnancy when blood hemoglobin is less than 11 g/dl at the beginning of pregnancy and less than 9.5 at the second and last trimester.
Hypertension	Systolic pressure/ Diastolic pressure = 120/80 mm Hg	<ul style="list-style-type: none"> ✓ Prehypertension: -Systolic pressure: (120 to 139) - Diastolic pressure: (80 to 89) ✓ The first stage of Hypertension: - Systolic pressure: (140 to 159) - Diastolic pressure: (90 to 99) ✓ The second stage: - Systolic pressure: (160 or more) - Diastolic pressure: (100 or more)
Coronary Heart	<ul style="list-style-type: none"> -Total cholesterol: less than 200 mg/dl - LDL cholesterol: less than 100 mg / dL - HDL cholesterol: more than 60 mg/dl - Triglycerides(TG): less than 150 mg/dl 	<ul style="list-style-type: none"> -Total cholesterol: more than 240 mg/dl - LDL cholesterol: more than 160 mg/dl - HDL cholesterol: less than 40 mg/dl -Triglycerides (TG): more than 200 mg/dl
Diabetes	<ul style="list-style-type: none"> - Fasting plasma glucose: less than 110 mg/dl -75 g Oral Glucose Tolerance Test (OGTT) at 2 h.: less than 140 mg/dl 	<ul style="list-style-type: none"> - Fasting plasma glucose: more than 126 mg/dl -75 g Oral Glucose Tolerance Test (OGTT) at 2 h.: more than 200 mg/dl

– **Input Personal Data**

A pregnant woman inputs her personal data through the user interface. Table3 presents a

description of advisory system inputs. Table 4 shows the description of physical activity types.

Table 3: Description of advisory system inputs

Input	Description
Age	<ul style="list-style-type: none"> • Adolescent: less than 19 years. • Adult: (19 and above) years.
Weight before pregnancy	(kg)
Current weight	(kg)
Height	(cm)
Pregnancy Stage	<ul style="list-style-type: none"> • 1st Trimester Pregnancy (1-3) months • 2nd Trimester Pregnancy (4-6) months • 3rd Trimester Pregnancy (7-9) months
Socio-Economic Status	- Low - Medium - High
Non-Preferred Food Items	Food items which pregnant woman does not prefer to eat.
Physical Activity	- Sedentary - Light Active - Active - Very Active

Table 4: The description of physical activity types [29]

Age	Sedentary	Low Active	Active	Very Active
Physical Activity Level	1.0–1.39	1.4–1.59	1.6–1.89	1.9–2.5
Description	Usual daily living activities (e.g., household tasks, walking to the bus)	Usual daily living activities PLUS 30–60 minutes of moderate daily activity (e.g., walking at 5–7 km/h)	Usual daily living activities PLUS at least 60 minutes of moderate* daily activity	Usual daily living activities PLUS at least 180 minutes of moderate daily activity

* **Some examples of moderate daily activity:** Household tasks with moderate effort, mopping, swimming (slow), vacuuming, and walking (4.83–6.44 km/h).

– **Calculate Body Mass Index**

Body Mass Index (BMI) is a ratio used to determine healthy weight ranges for humans.

BMI is defined as the weight in kilograms divided by the square of the height in meters. The height should measure with shoes off standing straight using a wall-mounted meter-stick (to the nearest 0.1 cm). The weight should be measured wearing light clothing (to the nearest 0.1 kg), and the BMI is calculated as follows [30-32]:

$$\text{BMI (Kg/m}^2\text{)} = \frac{\text{Weight (Kg)}}{\text{Height (m}^2\text{)}}$$

The National Institutes of Health and the World Health Organization (WHO) determine the body mass index for underweight, normal weight, overweight and obesity as the following table:

Table 5: The body mass index for underweight, normal and overweight [28-30].

Underweight (thin)	BMI < 18.5 Kg/m ²
Normal weight	BMI of 18.5–24.9 kg/m ²
Overweight	BMI of 25–29.9 kg/m ²
Obesity	BMI ≥ 30 kg/m ² .

– **Calculate Total Energy**

Energy from food is measured in Kcal (kilocalories) unit. The total energy can be obtained by calculating Estimated Energy Requirements (EER) for age, pregnancy energy needs and tissue deposition with the following equations [33]:

- *EER for females less than 19 years and BMI<25*

$$\text{EER for age} = 135.3 - (30.8 * \text{Age}) + \text{PA} * [(10.0 * \text{weight}) + (934 * \text{height})] + 25$$

Where:

Age: in years, Height: in meters, Weight: referred to the current weight of woman in kilograms, PA: The physical activity coefficient (PA=1.0 for sedentary, PA = 1.16 for low active, PA=1.31 for Active, PA = 1.56 for very Active)

- *EER for females greater than 19 years and BMI<25*

$$\text{EER for age} = 354 - (6.91 * \text{Age}) + \text{PA} * [(9.36 * \text{weight}) + (726 * \text{height})]$$

Where:

Age: in years, Height: in meters, Weight: referred to the current weight of woman in kilograms, PA: the physical activity coefficient (PA=1.0 for sedentary, PA=1.12 for low active, PA=1.27 for Active, PA=1.45 for very Active)

- *EER for females less than 19 years and BMI ≥ 25*

$$\text{EER for age} = 389 - (41.2 * \text{Age}) + \text{PA} * [(15.0 * \text{weight}) + (701.6 * \text{height})]$$

Where:

Age: in years, Height: in meters, Weight: referred to the current weight of woman in kilograms, PA: the physical activity coefficient (PA=1.0 for sedentary, PA=1.18 for low active, PA=1.35 for Active, PA=1.60 for very Active)

- *EER for females greater than 19 years and BMI ≥ 25*

$$\text{EER for age} = 448 - (7.95 * \text{Age}) + \text{PA} * [(11.4 * \text{weight}) + (619 * \text{height})]$$

Where:

Age: in years, Height: in meters, Weight: referred to the current weight of woman in kilograms, PA: the physical activity coefficient (PA=1.0 for sedentary, PA=1.16 for low active, PA=1.27 for Active, PA=1.44 for very Active)

$$\text{Total energy} = \text{EER for age} + \text{Pregnancy energy needs} + \text{tissue deposition}$$

- Total energy** in 1st trimester = EER for age + 0 + 0
- Total energy** in 2nd trimester = EER for age + 160 + 180
- Total energy** in 3rd trimester = EER for age + 272 + 180

– **Calculate Requirements of Nutrients**

The calculated energy (EER) distributed into the main macronutrients, proteins, fats, and carbohydrates. These macronutrients vary depending on the health status of the pregnant woman. Table 6 shows calculation of nutrients requirements for pregnant women in different health status [34-36].

Table 6: Calculation of nutrients requirements for pregnant women in different health status

Health Status	Nutrition Needs
<ul style="list-style-type: none"> ▪ Normal pregnant ▪ Pregnant suffered from anemia ▪ Pregnant suffered from Hypertension ▪ Pregnant suffered from Coronary Heart disease 	<p style="text-align: center;">Protein</p> <ul style="list-style-type: none"> ▪ Protein calories for an adolescent = 15% (EER) + 25 ▪ Protein calories for adult = 10% (EER) + 25 ✓ The number of protein grams = Calculated protein calories / 4 <hr/> <p style="text-align: center;">Fats</p> <ul style="list-style-type: none"> ▪ Fats calories = 25% (EER) ✓ The number of fats grams = Calculated fats calories / 9 <hr/> <p style="text-align: center;">Added Sugar</p> <ul style="list-style-type: none"> ▪ Added sugar calories = 10% (EER) ✓ The number of added sugar grams = Calculated fats calories / 4 <hr/> <p style="text-align: center;">Carbohydrates</p> <ul style="list-style-type: none"> ▪ Carbohydrates calories = EER – [Protein calories+ Fats calories+ Added Sugar calories] ✓ The number of Carbohydrates grams = Carbohydrates calories / 4
<ul style="list-style-type: none"> ▪ Pregnant suffered from diabetes. 	<p style="text-align: center;">Protein</p> <ul style="list-style-type: none"> ▪ Protein calories = 15% (EER) + 25 ✓ The number of protein grams = Calculated protein calories / 4 <hr/> <p style="text-align: center;">Fats</p> <ul style="list-style-type: none"> ▪ Fats calories = 25% (EER) ✓ The number of fats grams = Calculated fats calories / 9 <hr/> <p style="text-align: center;">Added sugar</p> <ul style="list-style-type: none"> ▪ Added sugar calories= 0 ✓ The number of added sugar grams = 0 <hr/> <p style="text-align: center;">Carbohydrates</p> <ul style="list-style-type: none"> ▪ Carbohydrates calories = EER – [Protein calories+ Fats calories] ✓ The number of Carbohydrates grams = Carbohydrates calories / 4

– Calculate Food Exchange Groups Per Day

Foods have divided into six groups in the food exchange system, which is designed by a

committee of the American Diabetes Association [37]. This system is beneficial for helping in planning meals, reducing blood & plasma glucose levels, maintaining lipid profile, helping in weight loss, and combating other diet-related diseases [38].

The food exchange groups divided according to the types and amounts of certain nutrients which contribute to the diet. Each food group contains a list of weighed or measured foods which have almost the same nutritional value. So, one exchange is including nearly the equal of protein, fat, carbohydrate, and energy with another in each food list [39]. Table 7 shows the food exchange groups [40-44].

Table 7: Food exchange groups

Food Group	CHO grams	Protein grams	Fat Grams	Energy
Starch/Bread	15	2	--	70
Meat/meat Substitute				
<i>Lean</i>	--	7	3	55
<i>Med. fat</i>	---	7	5.5	77.5
<i>High Fat</i>	---	7	8	100
Vegetables	5	2	--	25
Fruits	10	--	--	40
Milk				
<i>Skim</i>	12	8	----	80
<i>Low fat</i>	12	8	5	120
<i>Whole</i>	12	8	8	150
Fat	---	---	5	45

– Distribution of Food Exchange Groups and Food Items Per Meal

Distribution of food exchange groups per meal is done using the knowledge base. This knowledgebase can be reached using inference engine. Nutrition experts recommend that the pregnant woman takes five meals a day, namely; Breakfast (B), Lunch (L), Supper (S), Mid-morning snack (Sn₁) and Mid-afternoon snack (Sn₂). Table 8 shows an example of the distribution of food exchange groups per meal for pregnant women.

Table 8: Example of distribution of food exchange groups per meal for pregnant women

Food Group	Food Exchanges Units	B	L	S	Sn ₁	Sn ₂
Milk	3	1	-	1	1	-
Meat	4	1	2	1	-	-
Vegetables	7	1	3	1	1	1
Added Sugar	5	2	0	1	1	1
Bread	12	4	4	4	-	-
Fruits	8	2	1	1	2	2
Fats	10	2	2	2	2	2

After determining the undesired food items by the pregnant women and excluding these items from the knowledge base, a list of Egyptian food items for each food exchange group in each meal appears. This list is related to both socio-economic and health status of the pregnant woman. For example, table 9 shows different food lists from each exchange group in Breakfast meal for low socio-economic status.

Table 9: Different food lists from each exchange group in Breakfast meal for low socio-economic status

Group List	Egyptian Food List
Milk	<ul style="list-style-type: none"> • A cup of skimmed milk. • A cup of skimmed milk with tea.
Meat	<ul style="list-style-type: none"> • Half a cup of fava beans with oil. • Three medium-sized falafel. • Fried Egg • Boiled egg • 30 g low-fat white cheese. • 30 g Cottage cheese with oil.
Vegetables	One of tomato or one of cucumber.

Group List	Egyptian Food List
Fruit	<ul style="list-style-type: none"> • Two small-sized oranges. • Two of medium-sized tangerines. • Four large-sized dates.
Added Sugar	Two teaspoon sugar for milk + one and half teaspoon black Honey.
Fats	<ul style="list-style-type: none"> • <u>In case of (fava beans)</u> A Teaspoon of oil for fava beans (foul medames) + Two teaspoon tahini + Five large-sized green olives. • <u>In case of (falafel)</u> One teaspoon of oil for frying the falafel. • <u>In case of (fried egg)</u> One teaspoon of oil or ghee for frying the egg + One teaspoon tahini. • <u>In the case of (boiled egg)</u> Five large-sized black olives + Two teaspoons tahini. • <u>In case of (white cheese)</u> Five large-sized black olives + Two teaspoon - tahini + half tablespoon concentrated cream. • <u>In case of (cottage cheese)</u> A Teaspoon of oil for cottage cheese+ Two teaspoon tahini+ Five large-sized green olives.
Bread	<ul style="list-style-type: none"> • <u>In the case of fava beans or falafel</u> Three-quarters loaf of brown bread. • <u>In the case of egg or cheese</u> A loaf of brown bread

– **Detect the Desired Food Items in the Daily Meals**

The pregnant woman chooses her desired food items for each food group in each meal from the displayed lists. To make the right choice of the food items, the pregnant woman must read the general and specific nutritional advice that are suitable for her health status. Table 10 shows an example of the pregnant woman final meals.

Table 10: An example of the pregnant woman final meals

Group	B	L	S	Sn1	Sn2
Milk	A cup of skimmed milk	-----	A cup of skimmed milk with tea	A cup of skimmed milk	-----
Meat	A half cup of fava beans with oil	60 g small grilled fish	30 g low-fat white cheese	Boiled egg	-----
Vegetables	One tomato or one cucumber	Medium salad platter	One tomato or one cucumber	One tomato or one cucumber	-----
Fruit	Four large-sized dates	One of medium-sized tangerines	Two large-sized dates	One of small-sized orange	One of small-sized orange
Added sugar	Two teaspoon sugar for milk + one and half teaspoon black Honey	-----	Two teaspoons sugar	Two teaspoons sugar for a cup of lemon juice	One and a half teaspoon black Honey
Bread	Three-quarters loaf of brown bread	A cup and a third of the rice	A loaf of brown bread	A half loaf of brown bread	A half loaf of brown bread
Fats	One teaspoon of oil for fava beans + Two teaspoon tahini + Five large-sized green olives	One teaspoon of oil for cooking the rice + Two teaspoons tahini + One teaspoon of oil for salad	Five pieces of black olives large-size + 15 medium-size peanuts + Half tablespoon sunflower pulp without peel	15 medium-size peanuts	Two teaspoon tahini

C. User Interface

The user interface of the proposed advisory system is the most important step in this system. This step is used to interact between the pregnant woman and the system to display her final meals. It takes the pregnant woman's inputs in a readable form and passes it to the inference engine. Also, it includes text boxes, push buttons, popup menus and other input methods. In addition, it is designed in simple windows to help the pregnant woman to interact with it easily.

D. Nutritional Advice

This paper provides a set of nutritional advice for pregnant woman. This advice helps her to choose the appropriate foods that make up her daily meals. This choice of suitable foods is useful for her as it ensures the development of pregnancy naturally. Also, this advice presents foods that are forbidden to eat according to her health condition. These prohibited foods may pose risks to pregnancy continuation or threaten the health of the pregnant woman as well as the health of her fetus. Table 11 shows an example of some advice for pregnant woman who suffer from anemia.

Table 11. An example of some advice for pregnant woman who suffer from anemia

Allowed Foods	<ul style="list-style-type: none"> • Eat iron-rich foods by eating at least three servings a day, including lean red meat, poultry, fish and dark leafy vegetables such as spinach, broccoli, iron-rich grains, beans, lentils, nuts, and seeds, and eggs. • Foods rich in vitamin C should be taken with iron-rich foods as this promotes the absorption of more iron. Examples of foods rich in vitamin C are citrus fruits and juices, strawberries, guava, tomatoes, and peppers.
Prohibited Foods	<ul style="list-style-type: none"> • Avoid eating high-calcium foods with iron-rich foods. • Avoid eating foods rich in oxalic acid with iron sources at the same time (such as: parsley, peanuts, chocolate).

VI. APPLICATION AND EXPERIMENTAL RESULTS

The proposed advisory system for the nutrition of pregnant woman is designed using Matlab language (R2018b). The proposed advisory system Graphical User Interface (GUI) is shown in figure 2. Health status is chosen either normal, Hypertension, Diabetes, Anemia, or Coronary heart disease.

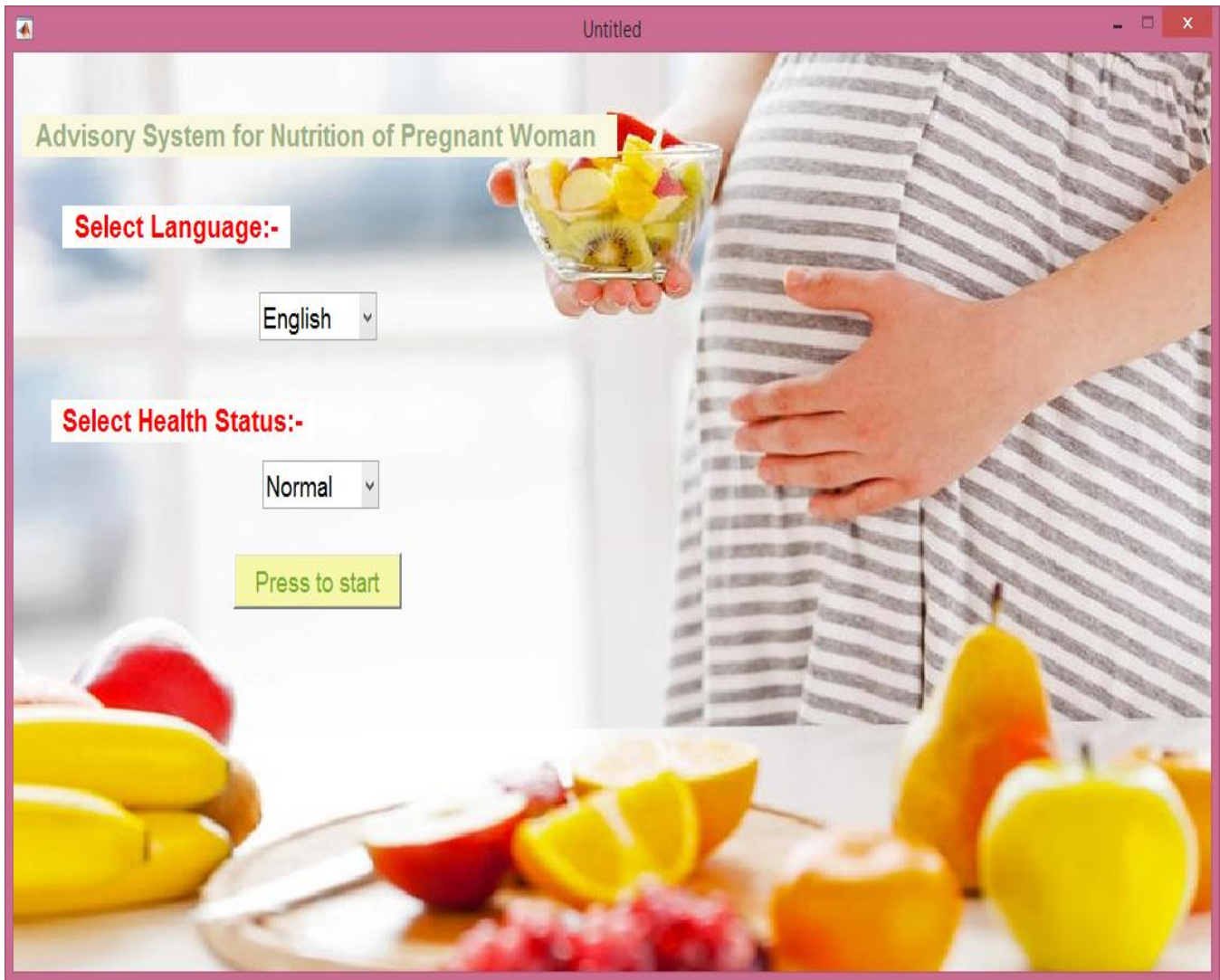


Fig 2: The proposed advisory system GUI

Figure 3 shows the main screen in case of the pregnant woman chooses normal from health status.

Normal_case_eng

Demographic Information
 Name Sama Ahmed Maged Age 22 Adult Height 160 Cm Current Weight 69 Kg Physical Activity Light Active Pregnancy Stages 3 rd trimesters (7-9)... Socio-economic Status Low

Calculate Body Mass Index Calculate Total Energy Calculate Proteins Needs Calculate Fat Needs Calculate Carbohydrates Needs

Body Mass Index
 Weight before pregnancy 57 Kg
 Body Mass Index 22.2656 Normal

Total Energy
 Total energy 2678.31 KCal

Protein
 Number of protein grams 92 g
 Protein Calories 368 KCal

Fat
 Number of fat grams 75 g
 Fat Calories 675 KCal

Carbohydrates
 Number of carbohydrate grams 408.828 g
 Carbohydrate Calories 1635.31 KCal

Units of Food Exchange Groups
 Meat 4 Units
 Milk 3 Units
 Bread 15 Units
 Vegetable 5 Units
 Fruits 7 Units
 Added Sugar 5 Units
 Fats 11 Units

Distribution of Food Exchange Units (Per Meal)

	Meat	Milk	Bread	Vegetables	Fruits	Added Sugar	Fats
Breakfast	1	1	4	1	2	2	2
Mid- morning Snack	0	1	2	0	2	1	3
Lunch	2	0	4	3	1	0	2
Supper	1	1	4	1	1	1	2
Mid- afternoon Snack	0	0	1	0	1	1	2

Identification of Non- Preferred Food Items

Milk Milk with tea Cottage cheese Fried Egg
 Yogurt Beans Falafel Boiled egg
 White cheese
 White beans Koshary Meat
 Fish Albesarh Kofta Fried chickens
 Orange Dates Black honey White honey
 Tangerines jam

Food Exchange System Displaying Final Meals

Selection of Food Items in each Meal

	Meat	Milk	Bread	Vegetables	Fruits	Added Sugar	Fats
Breakfast	Half a cup o...	A cup of ski...	Three-quart...	One of toma...	Two small-si...	Two teaspoo...	A Teaspoon...
Mid- morning Snack		A cup of ski...	Half a cup o...		Two of medi...	Two teaspoo...	15 medium-s...
Lunch	60 g small g...		A cup and a...	Medium sala...	One of the ...		One teaspoo...
Supper	Boiled egg ...	Two-thirds ...	A loaf of br...	One of toma...	Two large-si...	One and a h...	Five of black...
Mid- afternoon Snack			A quarter lo...		One of small...	One and a h...	One teaspoo...

Final Meal

Breakfast	Lunch	Supper
Half a cup of fava beans with oil A cup of skimmed milk Three-quarters loaf	60 g small grilled fish A cup and a third of the rice Medium salad platter One of the	Boiled egg Two-thirds cup of the skimmed yogurt A loaf of brown bread
Mid- morning Snack	Mid- afternoon Snack	
A medium Belila dish (Belila =Wheat with milk) Two of medium-sized tangerines	A quarter loaf of brown bread One teaspoon butter for jam+ 15 medium-size peanuts	

Home Page Nutritional Advice for Normal Food Exchange Lists Print Clear Exit

Fig 3: The main screen in case of choosing the normal from health status

Figure 4 shows general advice for a normal pregnant woman who do not suffer from any diseases. Following these advice helps her and her fetus to pass the pregnancy safely. Figure 5 displays foods that are allowed and prohibited for the normal pregnant woman. Consequently, the pregnant women increase the intake of desired foods as much as possible, while avoiding prohibited foods. Figure 6 shows food exchange lists. This figure displays six lists. These lists are fat, milk, bread, fruits, meat and vegetables exchange lists. Figure 7 shows a part of meat exchange list. This list provides the body with 7 grams of proteins, 5 grams of fat, 0 gram of carbohydrates, and 73 calories. Figure 7 shows that one meat exchange equals: one boiled egg, 30 g cheddar cheese, 30 g roast beef and so on.

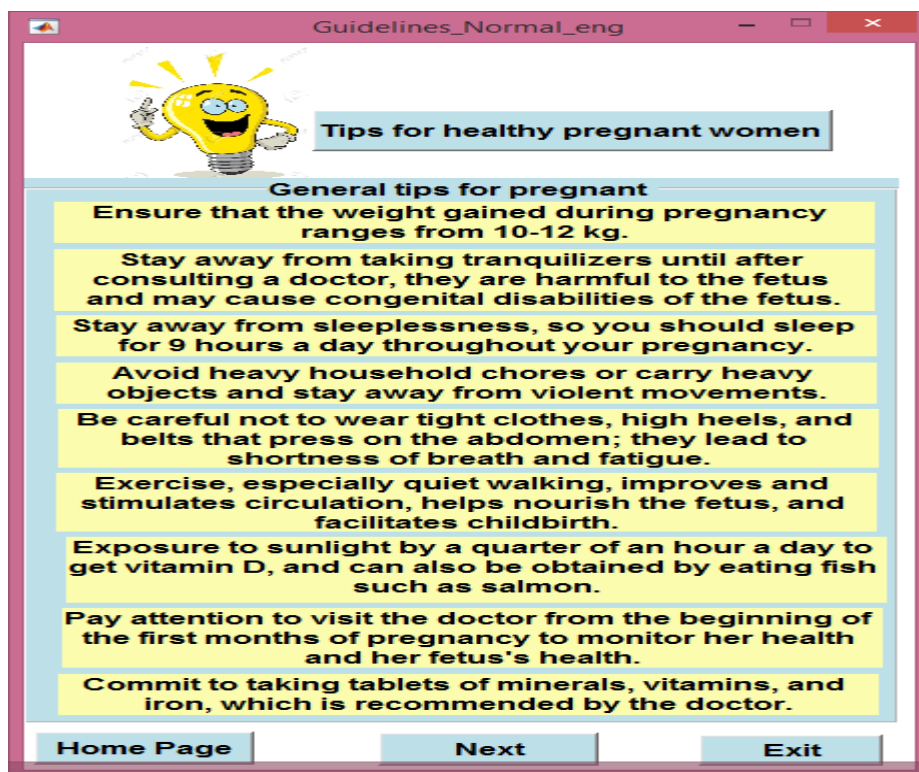


Fig 4: General advice for the normal pregnant woman

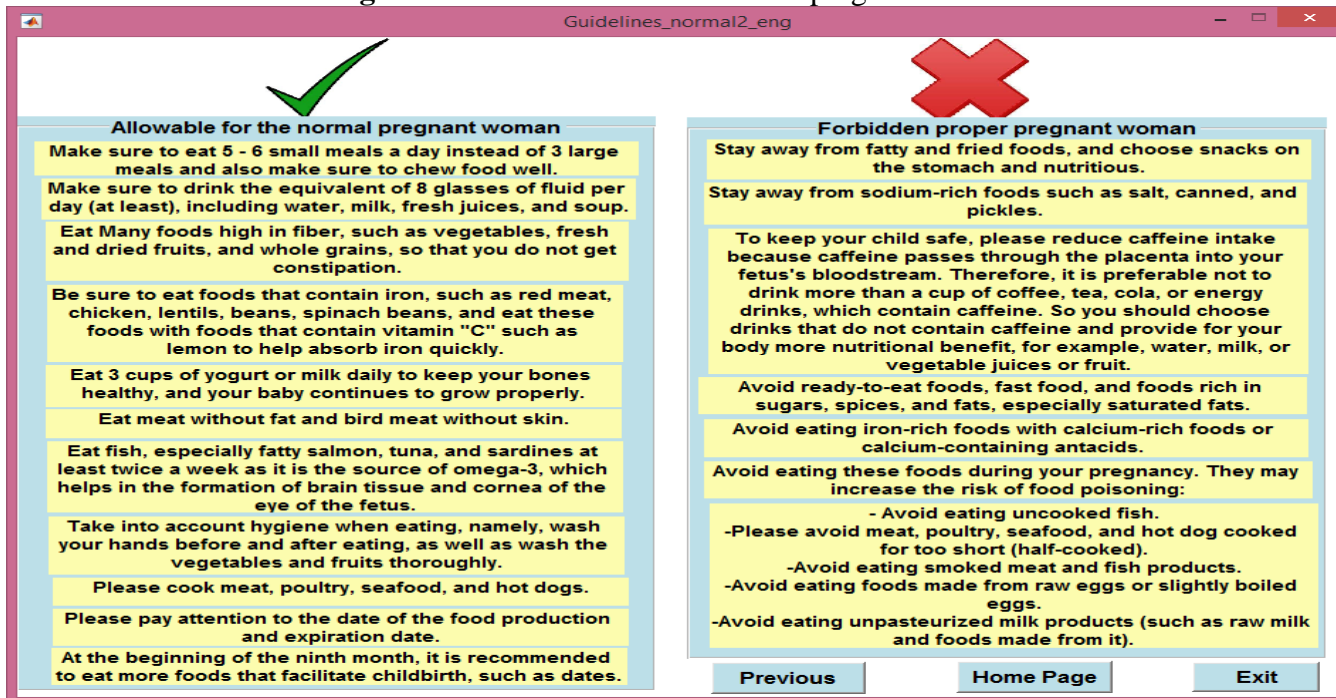


Fig 5: Foods that are allowed and prohibited for the normal pregnant woman

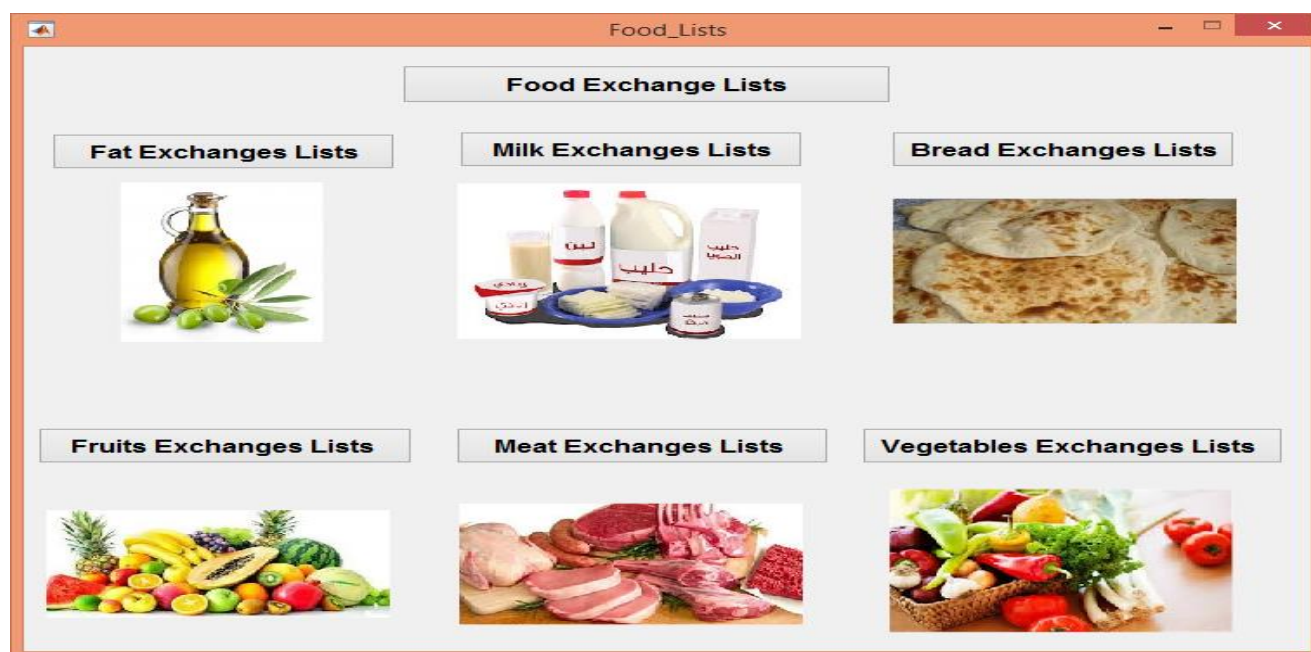


Fig 6: Food exchange lists

Item	Required quantity (1 serving)	Notes
Boiled eggs	1	
Fried eggs or omelet	1	deducted ½ unit of fat
Boiled egg whites	2	Add a fat unit
peanut butter	2 tbsp (= 2 table spoons)	deducted 2 fat
Cottage cheese	¼ cup	½ fat unit is added
Low-fat labneh	2 tbsp = 40 g	½ fat unit is added
Low fat white cheese (less than 3% fat)	30 g	½ fat unit is added
Full fat white cheese	30 g	½ Deducted fat unit
Cheddar cheese	30 g	½ Deducted fat unit
Rumi Cheese	30 g	
Mozzarella	30 g	
Ricotta cheese	30 g	
Cheese triangles	2 pieces	½ Deducted fat unit
Canned salmon without oil	¼ cup	½ fat unit is added
Canned tuna without oil	¼ cup	½ fat unit is added
Canned mackerel without oil	¼ cup	½ fat unit is added
Sardine drained	30 g (2 Small)	½ fat unit is added
Cooked red beef without skin and fat	30 g (in the size of two fingers)	½ fat unit is added
Roast Beef	30 g	½ fat unit is added
Veal (round - Shoulder - Neck)	30 g	½ fat unit is added
Veal (brisket)	30 g	½ Deducted fat unit
Minced meat 15% fat	30 g	

Fig 7: A part of meat exchange list

Figure 8 shows the main screen in case of the pregnant woman chooses diabetic from health status.

Diabetic_case_eng

Demographic Information
 Name Age Adult Height Cm Current Weight Kg Physical Activity Pregnancy Stages Socio-economic Status

Calculate Body Mass Index

Calculate Total Energy

Calculate Proteins Needs

Calculate Fat Needs

Calculate Carbohydrates Needs

Body Mass Index
 Weight before pregnancy Kg
 Body Mass Index Normal

Total Energy
 Total energy KCal

Protein
 Number of protein grams g
 Protein Calories KCal

Fat
 Number of fat grams g
 Fat Calories KCal

Carbohydrates
 Number of carbohydrate grams g
 Carbohydrate Calories KCal

Units of Food Exchange Groups:
 Meat Units
 Milk Units
 Bread Units
 Vegetable Units
 Fruits Units
 Fats Units

Distribution of Food Exchange Units (per meal):

	Meat	Milk	Bread	Vegetables	Fruits	Fats
Breakfast	<input type="text" value="2"/>	<input type="text" value="1"/>	<input type="text" value="4"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="2"/>
Mid- morning Snack	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="4"/>	<input type="text" value="1"/>	<input type="text" value="0"/>	<input type="text" value="1"/>
Lunch	<input type="text" value="2"/>	<input type="text" value="0"/>	<input type="text" value="4"/>	<input type="text" value="3"/>	<input type="text" value="0"/>	<input type="text" value="2"/>
Supper	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="4"/>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="2"/>
Mid- afternoon Snack	<input type="text" value="1"/>	<input type="text" value="0"/>	<input type="text" value="3"/>	<input type="text" value="1"/>	<input type="text" value="0"/>	<input type="text" value="1"/>

Identification of Non- Preferred Food Items
 Milk Milk with tea Falafel Boiled egg White cheese
 Yogurt Beans Cottage cheese
 White beans Fish Meat
 Koshary Albesarh kofta Orange Tangerines

Food Exchange System

Displaying Final Meals

Selection of Food Items in each Meal

	Meat	Milk	Bread	Vegetables	Fruits	Fats
Breakfast	<input type="text" value="Three medium-sized falafel"/>	<input type="text" value="A cup of skimmed milk"/>	<input type="text" value="Three-quarters loaf of brown bread"/>	<input type="text" value="One of tomato"/>	<input type="text" value="one small-size fruit"/>	<input type="text" value="One teaspoon of tahini"/>
Mid- morning Snack	<input type="text" value="30 g low-fat white cheese"/>	<input type="text" value="A cup of skimmed milk"/>	<input type="text" value="A loaf of brown bread"/>	<input type="text" value="A cucumber"/>		<input type="text" value="15 medium-size peanuts"/>
Lunch	<input type="text" value="60 g small grilled fish"/>		<input type="text" value="A cup and a third of the rice"/>	<input type="text" value="Medium salad platter"/>		<input type="text" value="One teaspoon of tahini"/>
Supper	<input type="text" value="Boiled egg"/>	<input type="text" value="A cup of skimmed milk"/>	<input type="text" value="A loaf of brown bread"/>	<input type="text" value="One of tomato"/>	<input type="text" value="one of medium-size fruit"/>	<input type="text" value="Five large-size nuts"/>
Mid- afternoon Snack	<input type="text" value="30 g low-fat white cheese"/>		<input type="text" value="Three-quarters loaf of brown bread"/>	<input type="text" value="a Tomato"/>		<input type="text" value="15 medium-size peanuts"/>

Final Meal

Breakfast	Lunch	Supper
Three medium-sized falafel+ Boiled egg A cup of skimmed milk Three-quarters loaf of brown bread	60 g small grilled fish A cup and a third of the rice Medium salad platter Two teaspoons tahini	Boiled egg A cup of skimmed milk A loaf of brown bread
Mid- morning Snack	Mid- afternoon Snack	
30 g low-fat white cheese A cup of skimmed milk A cucumber A loaf of brown bread 15 medium-size peanuts	30 g low-fat white cheese a Tomato 15 medium-size peanuts Three-quarters loaf of brown bread	

Nutritional Advice for Diabetics

Home Page

Food Exchange Lists

Print

Clear

Exit

Fig 8: The main screen in case of the pregnant woman chooses diabetic from health status

VII. CONCLUSIONS AND FUTURE STUDIES

Proper nutrition is the basis of successful pregnancy period, where attention is given to the health of the mother and fetal growth properly. A well-balanced diet will provide pregnant women with the essential nutrients they need each day. Consequently, there is an urgent need to develop an advisory system for pregnant nutrition. This work proposes a system for calculating calories and some

nutrients requirements of the Egyptian pregnant woman and distributes them in the daily meals. The importance of this research lies in ensuring adequate nutritional status for pregnant women, improvement of birth weights, the achievement of adequacy in all nutrients, and prevention of deficiency diseases.

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