



## Menu scheduling for high blood pressure patient with optimization method through integer programming

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### Abstract

The application of mathematical modelling technique was normally applied in various fields of study. It is the optimal solution that can help to solve various diet problems. Every diet problem has its specific objective functions and limitation of cost. The requirement of nutrient content, the amount of food intake and the price of food should be considered when planning a balanced diet menu. This paper focuses on the mathematical modelling techniques that are used by researchers in optimizing the diet problem and planning a diet menu that meet all the specification and constraints. Additionally, this paper demonstrates the usage of integer programming and improvement that can be done. An optimal approach is obtained to solve the menu scheduling for high blood pressure patient.

**Keywords:** mathematical modelling technique, diet problem, diet menu, integer programming, high blood pressure

### 1. Introduction

A well-balanced diet is a key to healthy lifestyle. It will provide the right amount of energy (calories) and the right amount of nutrient requires such as carbohydrates, fibre, proteins, fats, water, vitamins and minerals from all variety of foods and drinks to control the body weight, maintain energy balance and reduce the risk for health problems. Thus, a balanced diet is vital for every people especially those people who suffers from High Blood Pressure.

High blood pressure (HBP) also known as hypertension, it happens when the blood pressure in the blood vessels higher than normal pressure which exceed 140/90 mmHg which measured by using an Electronic Sphygmomanometer. High blood pressure is known as "silent killer", if not controlled, it may lead to many health problems such as cardiovascular disease, stroke, diabetes and others. Besides, high blood pressure had risen among the adult in Malaysia, one in three adult Malaysians are suffering from this disease. (New Straits Times, 2016) According to the Malaysian Society of Hypertension (MSH), this disease is affecting the younger people nowadays. (The Star Online, 2014).

Based on the previous study, the healthy lifestyle habits such as eating a healthy foods and exercise regularly may help to control and lower the blood pressure. Diet plays an important role in treating high blood pressure (hypertension). A well-balanced menu is needed for high blood pressure patient to help to decrease the risk of high blood pressure. High blood pressure should consume a diet that are rich in protein, fiber, potassium, magnesium which includes whole grains, fruits, vegetables, poultry, fish, nuts and low-fat dairy products. Besides, the patient should lower the level of sodium (salt) in their diet. They also should avoid to eat foods which contain high level of sugar and fats.

Most of the high blood pressure patients faced the problem in

choosing food that meet their nutritional needs and they do not clear on the amount of food that they should consume. Therefore, a healthy planning diet menu for high blood pressure patient which develop by mathematical model is an optimisation method in order to solve the diet problem. However, there are some consideration should be noted in preparing a diet menu such as cost constraint, desired nutritional content, amount of food intake and allergens of food.

### 2. Literature Review

The popularity of high blood pressure which know as hypertension is rising among the children and adolescents. This situation has become a serious public health issue which promoting a huge amount of research. The mild rise of blood pressure in children and adolescents is more common than previously thought. Generally, the abnormal blood pressure in youth will translate into adult hypertension that so-called tracking phenomenon. The blood pressure of children increases as their age and body size increase, this making the diagnostic standard unable to define hypertension using a single blood pressure level as done in adults. The early detection of abnormal blood pressure is very important because it will be an early awareness and prevention to reduce cardiovascular morbidity and mortality in the years later. (Webb & Wu, 2016) <sup>[14]</sup>

Menu planning is a way to discover a person eating a diet with balanced nutrition. The general menu planning concepts is crucial for the target groups who need help. The researchers had performed a project to prove that planning before eating is the key to beneficial dietary patterns by teaching the children to plan and prepare a diet menu. The project is conducted using survey method along with questionnaire. The children used the Web-based template named as Menu Planning Plate

to build and plan meals. The idea of the template was derived from an adjustment of DASH plate idea. (Dixon *et al.* 2014). Besides, menu planning is commonly used by the hospital catering department to ensure their quality of catering meet the needs and expectation of patients. The food provided by the hospital should meet the requirements of different groups of patients, to improve the support of nutritional and reduce the waste of food. Meeting the nutritional demands of patients will help them recover. Moreover, malnutrition in hospital can be improved by upgrading menu plan, modifying menus, and readjusting the atmosphere of mealtime. Hence, the hospital's catering department must be able to construct a balanced menu that achieves the nutritional requirements of patients. (Iff *et al.*, 2008)<sup>[7]</sup>.

### 2.1 Linear programming

Linear programming is a mathematical approach for maximizing or minimizing a linear function of a set of decision variables, while regarding numerous linear requirements. (Briend, Darmon, & Ferguson, 2003)<sup>[1]</sup> The application of linear programming technique was successfully applied in various fields of study. It can be used to predict economic growth, saving the resources, solve transportation systems problem and also diet problem.

Darmon & Ferguson (2002)<sup>[1]</sup> had done an optimization study to investigate the influence of cost constraint on the food choices of a person and the quality of nutritional. The researchers used the linear programming model to examine the food selection pattern and nutritional quality with the diet cost. This study consists of 361 male adults and 476 female adults aged 18 year old and above which located in France. The food composition in the model included 73 food items and 28 nutrients, the estimated cost of each food was also considered in the model. This model was developed by linear programming using Simplex procedure of the Premium Solver 3.5 for Excel. The results obtain shows that the food budget will affect the food choices and then the dietary quality. The cost constraint will minimize the nutritional content of diet and limit the selection of food of a person.

Besides, dos Santos *et al.* (2018)<sup>[5]</sup> used the linear programming model to identify an optimal food intake pattern that fulfil the nutritional advice to lower the prevalence of inadequate intake of nutrient ( $\leq 20\%$ ). This study was conducted in Brazil which consists of 25 324 adults aged 20 years and above, except pregnant women. There are 68 food items from the Brazilian nutritional survey included in the model, however there are some drinks like coffee without sugar, tea without sugar and alcoholic beverages are excluded in the model. The result obtains indicate that increase the intake of fruits, beans, vegetables, milk, fish and seafood, whole cereals and reduce the intake of sugar-sweetened beverages, rice, snacks, red meat and processed meat can help in optimized diet to develop a healthy eating habits. The researchers proposed that modifying the current food intake patterns will help to increase nutrition of the population and reduce their risk of nutrient inadequacy.

Normally a classical diet planning which develop by linear programming model has required vary quantities of nutrients from different variety of food with a minimum cost. However, Hreţcanu & Hreţcanu (2010)<sup>[6]</sup> replaced the minimum cost

with the minimum amount of calories. The researcher discovered the content of nutrient and quantities for the proposed daily menu which normally consume by a person using linear programming model. The total calories amount of the proposed menu is regarding the amounts of nutrient intake.

### 2.2 Integer programming

Integer Programming is one of the approach to optimize problems in which all of the variables are in discrete or integer values. When the problem of integer programming only required binary variables (0 and 1), it is known as binary integer programming. (Corrêa *et al.*, 2015)<sup>[2]</sup> Thus, some researcher used integer programming model for diet optimization as the outcome of the variables are in whole units. For example, Sufahani, Ismail, & Bahru (2014)<sup>[13]</sup> carried out a research using the integer programming model to construct a well-balanced nutritious daily menu that meet the nutrient recommendations of Malaysian RDA for secondary children aged 13 to 18 years old by reducing the total diet cost. The model included 10 food groups such as beverage, cereal flour based, rice flour based, cereal based meal, meat dishes, seafood, vegetables, fruits, wheat flour based and miscellaneous which included 426 dishes and containing 11 nutrients. The price of each food was also considered in the model. The objective function to lowering the total diet cost (F):

$$F = \sum_{i=1}^{426} c_i x_i$$

Subject to the constraints:

$$LB \leq \sum_{i=1}^{426} Nutrients(x_i) \leq UB$$

11 nutrients requirement:

$$\sum_{i=1}^{10} Type\ of\ foods(x_i) = n$$

10 type of food groups:

Where

- = the cost of each dishes;
- = the dishes number.
- = lower bound value of each nutrient
- = upper bound value of each nutrient
- = the number of food requirement per day

Based on the study, the researchers had prepared a nutritious menu which includes six types of meals in one day and every meal has different daily intake requirement: 6 beverages, 1 cereal flour based, 1 rice flour based, 2 cereal meal based, 1 meat, 1 seafood, 2 vegetables, 2 fruits, 1 wheat flour based and 1 miscellaneous with a total diet cost less than RM15.00. Moreover, Sheng *et al.* (2017) done a similar research using same formulation to construct a suitable one day menu for the eczema patients at different conditions with lowest cost. However, the model of the research consists of 18 food items from 10 food types with only 100 variables.

### 2.3 Goal programming

Goal Programming is a technique which make use of the generalised and developed of Linear Programming to handle multiple objective decision analysis. It provides a

simultaneous solution to solve the several competing goals. It can reduce the bias between goals and what can be obtained in the given set of constraints. The deviational variable is denoted as positive and negative variations from every goal. (Sinha & Nabendu Sen, 2011) [12] The general of goal programming model can be formulate as follow:

$$\text{Minimize } Z = d^- + d^+$$

where  $d^-$  and  $d^+$  are negative and positive deviational variables. In order to obtain the subject to the given constraints:

$$f(x) = \sum_{j=1}^n C_j X_j = CX$$

Generally, some researchers may apply goal programming technique in diet optimization. Pasic *et al.* (2012) [10] proposed a goal programming model which to develop a menu planning system by reducing the deviations of micronutrients and macronutrients needs and minimize the daily food cost based on the household food budget. This research conducted in the capital of Bosnia and Herzegovina with the 50 random samples of households. There are 55 commonly consumed food items considered as decision variables in this research. The results of the model illustrated that woman and man who involved in this research have meet all of the nutrients needs as all the deviational variables for nutrient needs equal to zero.

### 2.4 Fuzzy linear programming

Fuzzy linear programming is one of the forms for linear programming problem. It is utilized to locate the best solution possible with imprecise, unclear, unreliable or insufficient information. The researchers Mamat *et al.* (2011) [9] employed fuzzy linear programming to determine the changes of food prices and to optimize diet problem with fuzzy price. There are 40 types of food, 26 types of nutrients contained in this research. The food price (in RM) which collected from the Terengganu local grocery stores was also considered in this research and assumed as fuzzy numbers. The results obtained by fuzzy approach shows that the less amount of carbohydrate is the most expensive diet. The estimation of the diet menu is affected by the uncertainty of food prices. However, people are still able to meet their amount of nutrients required in low food cost.

In the next year, the researchers proposed a nutrient balanced menu for Eating Disorder and disease-related lifestyle with minimum cost by using the same programming. The fuzzy linear programming is used to assess the nutrition needs and to determine the amount of nutrient in daily food intake by human. The planning menu provides nutrition which achieved the human nutritional requirements in daily routine and help those people to have healthy food choices with minimum cost. (M., N.F., S.K., & N.M., 2012) [8].

**Table 1:** Summary of Previous Study on Mathematical Modelling Technique

Author (year)	Technique	Research Problems
Darmon & Ferguson (2002) [3]	Linear Programming	To investigate the influence of cost constraint on the food choices of a person and the quality of nutritional. The food items included in the research are limited and the amount of food consumed by the adults is based on the actual French diet pattern.
dos Santos <i>et al.</i> (2018) [5]		To identify an optimal food intake pattern that fulfil the nutritional advice to lower the prevalence of inadequate intake of nutrient ( $\leq 20\%$ ). The food composition data set in the research is insufficient to be used as a list of food and nutrient in national surveys.
Hreţcanu & Hreţcanu (2010) [6]		To determine the content of nutrient and quantities for the proposed daily menu which normally consume by a person. The food items included by the researcher in the research are limited.
Sufahani <i>et al.</i> (2014) [13]	Integer Programming	To construct a well-balanced nutritious daily menu that meet the nutrient recommendations of Malaysian RDA for secondary children aged 13 to 18 years old by reducing the total diet cost. The researchers focused too much on the school children who aged between 13 to 18 years old at secondary boarding school.
Sheng <i>et al.</i> (2017) [11]		To construct a suitable one day menu for the eczema patients at different conditions with lowest cost. The daily menu planning is prepared only for patient with eczema disease.
Pasic <i>et al.</i> (2012) [10]	Goal programming	To develop a menu planning system by reducing the deviations of micronutrients and macronutrients needs and minimize the daily food cost based on the household food budget. The food type is not considered in the research since the menu is plan for daily needs
Mamat <i>et al.</i> (2011) [9]	Fuzzy Linear Programming	To determine the changes of food prices and to optimize diet problem with fuzzy price. The food price in the research is insufficient to be used in national surveys since it only collected from the local grocery stores in Terengganu.
Mamat <i>et al.</i> (2012)		Proposed a nutrient balanced menu for Eating Disorder and disease-related lifestyle with minimum cost. There are some macronutrients do not involve in the model of this research.

**Table 2:** Contributions of the Research using Integer Programming

1	To construct a diet menu for high blood pressure patient
2	To discover the amount of nutrient require of high blood pressure patient.
3	To identify the range of specific nutritional requirement.
4	To prepare a daily menu scheduling.
5	Identify the solutions for high blood pressure patient.
6	The meal included all essential nutrient and 426 food items.
6	To minimize the diet cost for high blood pressure patient.

### 3. Discussion

This section has focus on the studies done by the previous researchers. The previous studies had discussed the application of various types of mathematical modelling technique in optimizing the diet problem with constraints. Table 1 shows the comparison of previous study on mathematical modelling technique and the lack of each previous study while table 2 illustrates the contributions using integer programming which can be approved in the research. There is some further improvement should be done in this research.

### 4. Conclusion

A diet menu that meets nutritional requirements can be constructed by different mathematical modelling technique as well as minimizing the food cost. Besides, the specific nutrition requirement of human also can be determined by the optimization technique. This review helps to understand the use of mathematical programming in solving diet problems with its constraint. The further study can be extended to prepare a well-balanced diet plan that suitable for high blood pressure patients which fulfils their requirements and restrictions by using the optimization approach. This paper can help to explore the information of optimizing diet problems and to promote a healthy lifestyle.

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