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# APPLIED MATHEMATICAL OPTIMIZATION TECHNIQUE ON MENU SCHEDULING FOR COVID-19 PATIENTS USING MATLAB PROGRAM

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**Abstract:**

People needs to eat well balanced nutritious food which includes proper calories, vitality and supplements for legitimate development, keeping in mind the end goal is to repair and support the body tissues and averting undesired ailments and disease. In recent studies, medical researchers have discovered thatgood nutrition can help to reduce the risks of coronary heart disease and types ofcancer. Menu and diet planners face tremendous challenges and difficulties in orderto improve human health. The aim of this study is to develop a mathematicalmodel for diet planning that meets the necessary nutrient intake and the minimizinga budget. Therefore the model was solved by using optimization methodalong with Integer Programming. This model can be adopted to solve other dietplanning problems such as for the military, schools and universities.

Key words: Decision Making, Mathematical Modelling, Optimization, Integer Linear Programming, Menu Planning, Health Department.

## 1. INTRODUCTION

Nutrition is affected by numerous environmental and societal causes. Although the diet problem were already urgent during World War II , the challenge of feedingthe world in a healthy and sustainable manner will only become more urgent. Thefirst studies applying LP to diets were published between 1950 and 1960. The searchfor diet solutions started with Jerry Cornfield, who formulated ”The Diet Problem”for the Army during World war II (1941-1945), in search of a low-cost diet thatwould meet the nutritional needs of a soldier. The Covid-19 pandemic that has spread rapidly and extensively around the world since late 2019 has had profound implication for food security and nutrition. Hence examine on menu arranging by creating mathematical model utilizing operational research and decision making.MATLAB with the LP Solve Programming language was used to solve the problem.

There are many methods that can be used to solved LP Problem such as graphicaland simplex method. It consumes a lot of time to solve the LP model manually byusing these methods. This paper applied the LP to determine the minimum cost offood for the patients and the LP model are solved using MATLAB program[1].

## 2. COVID-19 PATIENTS

During the situation of Covid-19 many people are affected by this disease.Whena person got positive in Covid-19 they should follow the diet plan to get some immunitypower.So the Health Department is responsible for planning menus for thepatients based on the cost of food items.The menu lists are given to caterers in hospitalwho provide six meals per day, breakfast[B], Morning tea[M], Lunch[L], EveningTea[E], Dinner[D] and Supper[S].The menu provided is a non-selective menu wherethe patients do not have the choice to choose the preferred foods[2].The primary purposeof this research paper is to develop a mathematical model that could lead to thecreation of menu lists. We tried to minimize the budget provided by the governmentand fulfill the requirements of the Covid-19 patients.Furthermore we had hoped tomaximize the variety and fulfill the consumers’ preferences. Hence, research on menu planning by developing mathematical models, which use operational research anddecision science techniques, is important in order to help caterers provide nutritiousmeals over extended time periods within the limited budget allocation.

A proper diet can help to ensure that the body is in the strongest possible state to battle the virus.The food safety management system must provide food safetyofficials and workers with proper personal protective equipment to avoid contamination,researchers

have found that there is no source of virus contamination viafood packaging or food.However,good food practices are always recommended byfollowing them to minimize the risk of contamination.

**Definition 1.*Mathematical Model:***

This model is an attempt to study somepart (or form) of the real-life problem in mathematical terms. Conversion of physicalsituation into mathematics with some condition.

**Definition 2.*Optimization Method:***

This method is used in many areas of studyto find solutions that maximize or minimize some study parameters, such as minimizecosts in the production of a good or service, maximize profits, minimize rawmaterial in the development of a good, or maximize production.

**Definition 3. *Linear Programming***:

Linear Programming is a process of optimizing the problem whichare subjected to certain constraints. It means that it is the process of maximizing orminimizing the linear functions under linear inequality constraints. The problem ofsolving linear program is considered as the easiest one.

**Definition 4.*Integer Programming***

The optimization of a linear function subjectto a set of linear constraints over integer variables. An Integer Programmingis a mathematical optimization or feasibility program in which some or all of thevariables are restricted to be integer.

## 3. DATA COLLECTION

There are a few sorts of information expected to construct a menu arranging model. These incorporate the institutionalized cost of every menu, suggested wholesomeday by Recommended Daily Allowance (RDA) which incorporate with recommendeddaily intake of every supplement and nutrient for the patients in hospitaland the government spending plan for food providers. There are 6 supplements considered;Protein, Carbohydrates, Fibre, Iron, Fat and Calories, as shown in Table 1.Moreover 14 sorts of food be considered in this study, Egg, Idly, Elachi banana, Milk,Ragi Porridge, Fresh Dates, Dosa, Papaya, Palak Soup, Dal, Curd, Muskmelon, Paneerand Almond.

Table 1. Recommended Daily Intake

| Nutrient | Recommended Daily Intake |
|---|---|
| Protein | 55 |
| Carbohydrates | 180 |
| Fibre | 30 |
| Iron | 17 |
| Fat | 46 |
| Calories | 1800 |

Hence, based on the recommended daily nutrient above, the linear programming models are set up as follows [3]:

Minimize Z= c1x1+c2x2+c3x3+.....+cnxn

Subject to:

$$a11x1 + a12x2 + ... + a1nxn \geq 55$$

$$a21x1 + a22x2 + ... + a2nxn \geq 180$$

$$a31x1 + a32x2 + ... + a3nxn \geq 30$$

$$a41x1 + a42x2 + ... + a4nxx \geq 17$$

$$a51x1 + a52x2 + ... + a5nxx \geq 46$$

$$a61x1 + a62x2 + ... + a6nxx \geq 1800$$

$$x1, x2, ...xn \geq 1$$

Since the data collected is based on the menu provided by the hospital management, hence the LP model will be set up based on the price of food determined bythe management. The following are the example of food that contain nutrient for the covid patients [4].

Table 2. Types of Food

| Menu Label | Menu Name | Price |
|---|---|---|
| x1 | Egg | 5.00 |
| x2 | Idly | 4.00 |
| x3 | Elachi Banana | 7.00 |
| x4 | Milk | 15.00 |
| x5 | Ragi Porridge | 15.00 |
| x6 | Fresh Dates | 20.00 |
| x7 | Dosa | 5.00 |
| x8 | Papaya | 10.00 |
| x9 | Palak Soup | 10.00 |
| x10 | Dal | 7.00 |
| x11 | Curd | 10.00 |
| x12 | Muskmelon | 12.00 |
| x13 | Paneer | 25.00 |
| x14 | Almond | 20.00 |

## 4. IMPLEMENTATION

The following are the Nutritional content of menu for patients [5] (table 3).

Hence, based on the information the LP model is as follow[6]:

$$\text{MinimizeZ} = 5x1 + 4x2 + 7x3 + 15x4 + 15x5 + 20x6 + 5x7 + 10x8 + 10x9 + 7x10 + 10x11 + 12x12 + 25x13 + 20x14$$

Table 3. Nutritional content of menu for patients

| Menu | x1 | x2 | x3 | x4 | x5 | x6 | x7 | x8 | x9 | x10 | x11 | x12 | x13 | x14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Protein | 13 | 3 | 1 | 8.14 | 13 | 0.17 | 2 | 2 | 7.2 | 25 | 3.5 | 0.8 | 18.3 | 6 |
| Carbohydrates | 1.1 | 12 | 18 | 12 | 32 | 5.33 | 15.6 | 30 | 7.1 | 8 | 4.7 | 8 | 6 | 6.1 |
| Fibre | 0 | 0.3 | 3.07 | 0 | 3 | 0.6 | 0.8 | 5 | 2 | 12 | 0 | 0.9 | 0 | 3.5 |
| Iron | 1.89 | 5 | 0.1 | 0 | 0.1 | 0.07 | 0 | 0.2 | 2.7 | 7.57 | 0.1 | 0.1 | 2.16 | 10 |
| Fat | 11 | 0.1 | 0 | 8 | 1 | 0.03 | 5.1 | 0.5 | 2.4 | 1.2 | 3.3 | 0.2 | 27 | 14.2 |
| Calories | 72 | 58 | 105 | 122 | 354 | 20 | 133 | 119 | 37 | 147 | 4.7 | 34 | 265 | 164 |

Subject to:

$13x1 + 3x2 + x3 + 8.14x4 + 13x5 + 0.17x6 + 2x7 + 2x8 + 7.2x9 + 25x10 + 3.5x11 + 0.8x12 + 18.3x13 + 6x14 \geq 55$

$1.1x1 + 12x2 + 18x3 + 12x4 + 32x5 + 5.33x6 + 15.6x7 + 30x8 + 7.1x9 + 8x10 + 4.7x11 + 8x12 + 6x13 + 6.1x14 \geq 180$

$0x1 + 0.3x2 + 3.07x3 + 0x4 + 3x5 + 0.6x6 + 0.8x7 + 5x8 + 2x9 + 12x10 + 0x11 + 0.9x12 + 0x13 + 3.5x14 \geq 30$

$1.89x1 + 5x2 + 0.1x3 + 0x4 + 0.1x5 + 0.07x6 + 0x7 + 0.2x8 + 2.7x9$

$+ 7.57x10 + 0.1x11 + 0.1x12 + 2.16x13 + 10x14 \geq 17$

$11x1 + 0.1x2 + 0x3 + 8x4 + x5 + 0.03x6 + 5.1x7 + 0.5x8 + 2.4x9$

$+ 1.2x10 + 3.3x11 + 0.2x12 + 27x13 + 14.2x14 \geq 46$

$72x1 + 58x2 + 105x3 + 122x4 + 354x5 + 20x6 + 133x7 + 119x8 + 37x9$

$+ 147x10 + 4.7x11 + 34x12 + 265x13 + 164x14 \geq 1800$

$x1,x2,x3,x4,x5,x6,x7,x8,x9,x10,x11,x12,x13,x14 \geq 1$

Each food could only be served once in a day. This present study involved manydecision variables, constraints and parameters. The coding was programmed using Matlab with LP Solve and the optimal solution for a one day menu was obtainedwithin 1 second. This is really fast comparing to other techniques where it wouldhave taken more than 4 hours or even a day. The efficiency of the methods in solvingthis menu planning problem has been proven based on past studies [7,8]. Here aresome example which are solved by using the Matlab Program.

```
>>A = - [13 3 1 8.14 13 0.17 2 2 7.2 25 3.5 0.8 18.3 6;
 1.1 12 18 12 32 5.33 15.6 30 7.1 8 4.7 8 6 6.1;
 0 0.3 3.07 0 3 0.6 0.8 5 2 12 0 0.9 0 3.5;
 1.89 5 0.1 0 0.1 0.07 0 0.2 2.7 7.57 0.1 0.1 2.16 10;
 11 0.1 0 8 1 0.03 5.1 0.5 2.4 1.2 3.3 0.2 27 14.2;
 72 58 105 122 354 20 133 119 37 147 4.7 34 265 164];
>>b = - [55 180 30 17 46 1800]';
>>f = [5 4 7 15 15 20 5 10 10 7 10 12 25 20]';
>>lb = [1 1 1 1 1 1 1 1 1 1 1 1 1 1]';
>>x = linprog (f, A, b, [], [], lb)
Optimal solution found.
X =
      1.0000
      1.0000
      1.0000
      1.0000
      1.0000
      1.0000
      2.2429
      1.0000
      1.0000
      1.0000
      1.0000
      1.0000
      1.0000
      1.0000
>>-A*x
Ans =
     1.0e+03 *
        0.1056
        0.1853
        0.0322
        0.0300
        0.0804
        0.8000
>> f'*x
Ans =
        171.2143
```

## 5. RESULT

The result are presented in Table.4.It shows meals for one day to be provided by the management of the hospital to the patients. In Table 4,we can see there is avariety of drinks and foods presented in different ways for one day, which includes six types of meals from breakfast to supper.All these drinks and foods meet the dailynutritional requirements for the patients in hospital at minimum cost.Therefore, itcan be concluded that all the meals chosen are nutritious and are advisable to beserved to the patients.The value of the total cost is less than the budget providedby the management.This means the management of the hospital will spend lessthan$200 per day.

Table 4. One day menu

| Types of Meals | Types of Food |
|---|---|
| Breakfast | Idly, Milk and Papaya |
| Morning Tea | Muskmelon |
| Lunch | Egg, Ragi porridge, Dal and Curd |
| Evening Tea | Palak soup, Almond |
| Dinner | Dosa, Panner |
| Supper | Elachi banana, Fresh dates |

## 6. CONCLUSION

In this paper we have produced a suitable one day menu plan that can be used asa guide for the management of the school. The model was solved using MATLABwith LP solve. It fulfills all the constraints by the researchers and gives a better solutioncompared to other heuristic methods, such as Genetic Algorithm.This researchfocused on patients in the hospitals. The total cost for one day is $171.21.Therefore,we can serve slightly expensive and better quality of foods for the patients.An approachusing post-optimality and sensitivity analysis will be developed in the futurebased on the changes in the coefficient value[11,12].

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