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Diet Recommendation for Cardiovascular Disease Patients Using Fuzzy Linear Programming Problem

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ABSTRACT: In this paper we discuss about the diet and also the risk factors associated with cardio vascular disease. The global cardio problem has increased over the years. The major risk factors are hypertension, obesity, physical activity and mental stress. But the most common and increasing risk factor is hypertension (or) blood pressure by controlling it can avoid the cardiovascular disease(CVD), whereas the Diet control is a concern for the present decade generation. The study progress a diet problem, subject to the calories needed for daily consumption, the budget for the diet, and the healthiest distribution for meals in a day. The optimum solution that is to find the quantity of food items that should be consumed to minimize the cost of diet. Here the numerical examples for both cases have been discussed and solved are shown below.

KEYWORDS: Linear Programming, Optimal, Diet, Minimization, Fuzzy, linguistics variables.

I. INTRODUCTION

In this decade of life is busy for human life. Life requires energy in work and caring for family. Keeping up with demand can be difficult. Thus, people tend to take the easiest option with their food choices, like eating fast food, consuming more food than needed, or eating extra snacks between meals. Extreme choices often lead to a serious health problems including diabetes, high blood pressure and etc... [11,1]. Although there is ample data on the burden of risk factor such as hypertension in the Indian population [14]. Poor hypertension control might have been one of the primary reason for cardiovascular events in our cohort. Hypertension is a high priority risk factor in the context of India, which is home to 200 million adults with raised BP among nearly a billion adults with elevated BP globally. Mean systolic BP of South Asian population, including India, showed an upward trend over the past decades, unlike high-income western countries [12]. Cardiovascular disease (CVD), specifically coronary heart disease and stroke, is the leading cause of death and disability-adjusted life years for all regions of the world [10]. The first diet problem [13] focused on minimizing the cost of food. by minimizing the cost of food which can also afford for financially low level peoples. The numerous studies have magnified our understanding of the relationship between diet and cardiovascular health [4]. The linear programming was first formally solved the problem by using simplex method and it is developed [3] in 1948 and by the continuous of that [5] the lead to the theory of linear programming by Dantzig as the maximization of a linear function subject to linear inequality constraints with this, a detailed version was developed [2] as Linear programming (LP) is used for optimizing (maximizing or minimizing) a linear function of many variables. He [8] proposed a fuzzy linear programming approach for finding the exact solution of fully fuzzy linear system (FFLS) of equations. There proposed a method to obtain the approximation solution of FFLP problems [6].

II. MATHEMATICAL FORMULATION

The Linear Programming problem can be put in the following form, which is also known as standard form of LPP [11].
Maximize (or Minimize)

$$Z = c_1x_1 + c_2x_2 + \dots + c_nx_n \text{ (Objective Function)}$$

Subject to the constraints;

$$a_{11}x_1 + a_{12}x_2 + \dots + a_{1n}x_n (\leq, =, \geq) b_1$$

$$a_{21}x_1 + a_{22}x_2 + \dots + a_{2n}x_n (\leq, =, \geq) b_1$$



$$a_{m1}x_1 + a_{m2}x_2 + \dots + a_{mn}x_n (\leq, =, \geq) b_1;$$

Where $x_1, x_2, \dots, x_n \geq 0$.

III. METHODOLOGY

In this paper, simplex method and fuzzy linear programming problem are used and illustrated two numerical illustration.

IV. NUMERICAL ILLUSTRATION

4.1. To test the major risk factor of CVD, we take 30 villages of kancheepuram district, on testing the systolic blood pressure in the age group of 40 to 79 the survey of 489 total people in that 158 men and 331 women are presented, by analysing the BP level from normal to high stage 2 hypertension are collected and given in the following tab

Table 1: SYSTOLIC BLOOD PRESSURE

AGE GROUP	<120	120-139	140-159	>160	TOTAL
40-49	106	38	43	12	199
50-59	57	35	37	14	143
60-69	38	23	32	15	108
70-79	14	4	11	10	39
TOTAL	215	100	123	51	489

The above data is collected from the researchgate website which is updated in the month of April 1, 2015 [7]. From the data the range and linguistic variable are taken

Range Linguistic variable	
Less than 120	normal
120 – 139	pre hypertension
140 – 159	high stage1 hypertension
Above 160	high stage2 hypertension

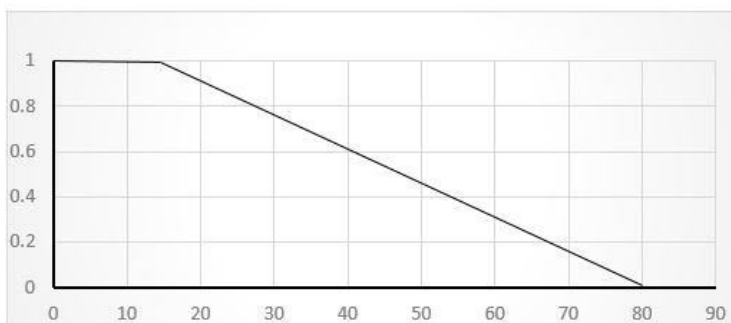
We formulated the BP levels as,

1)NORMAL (less than 120):

$$A_1 = 1 \quad \text{if } x \leq 30$$

$$\frac{60-x}{30} \quad \text{if } 30 \leq x \leq 60$$

$$0 \quad \text{if } x \geq 60$$



The objective function:

$$\text{MAX } Z = 215x_1$$

Subject to constraint:

$$14x_1 \leq 30$$

$$38x_1 \leq 60$$

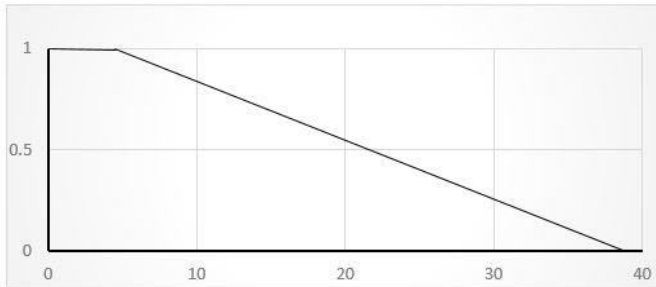
$$x_1 \geq 0$$

Solution: $x_1 = 1.5789$ and $\text{MAX } Z = 339$



2)PRE HYPERTENSION (120 – 139):

$$A_2 = \begin{cases} 1 & \text{if } x \leq 10 \\ \frac{30-x}{15} & \text{if } 10 \leq x \leq 30 \\ 0 & \text{if } x \geq 30 \end{cases}$$



The Objective function:

$$\text{MAX } Z = 160x_1$$

Subject to constraint:

$$4x_1 \leq 10$$

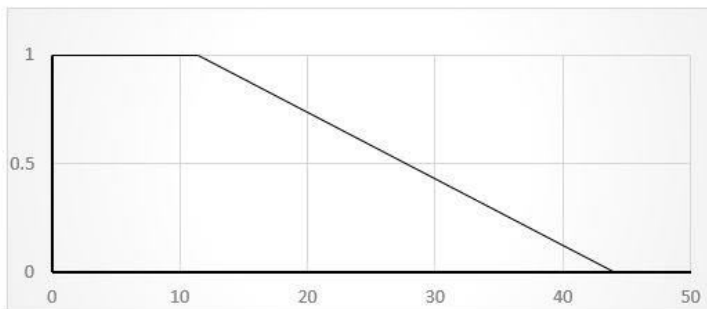
$$23x_1 \leq 30$$

$$X_1 \geq 0$$

Solution: $x_1 = 1.3043$ and $\text{MAX } Z = 130.4$

3)HIGH: STAGE-1 HYPERTENSION (140 – 159):

$$A_3 = \begin{cases} 1 & \text{if } x \leq 20 \\ \frac{35-x}{15} & \text{if } 20 \leq x \leq 35 \\ 0 & \text{if } x \geq 35 \end{cases}$$



The objective function:

$$\text{MAX } Z = 123x_1$$

Subject to constraint:

$$11x_1 \leq 20$$

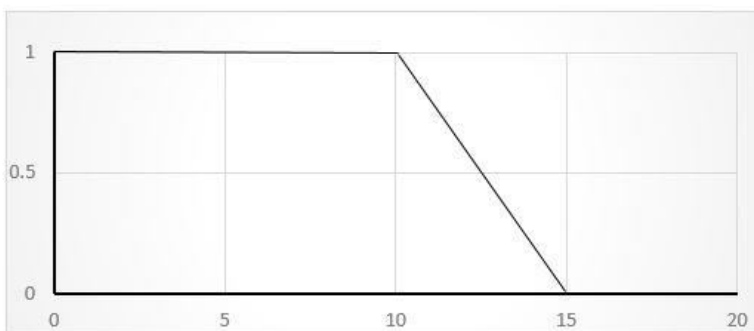
$$32x_1 \leq 35$$

$$X_1 \geq 0$$

Solution: $x_1 = 1.0938$ and $\text{MAX } Z = 134.5$

4)HIGH: STAGE-2 HYPERTENSION (above 160):

$$A_4 = \begin{cases} 1 & \text{if } x \leq 10 \\ \frac{15-x}{8} & \text{if } 10 \leq x \leq 15 \\ 0 & \text{if } x \geq 15 \end{cases}$$



The objective function:

$$\text{MAX } Z = 51x_1$$

Subject to constraint:

$$11x_1 \leq 10$$

$$14x_1 \leq 15$$

$$X_1 \geq 0$$

Solution: $x_1 = 1$ and $\text{MAX } Z = 51$



From solving the above four objectives we get a value of x_1 as 1. So the membership value of 1 in each range lies at 10%. The people in village has gradual increasing in BP at all levels. So the people are concerned to take proper diet and stress free activity

4.2. To control the heart problem, the consumed food should be monitored and prepared. The type of foods and the amount is to be noted. As a result, cost was considered a constraint. Therefore, a variation of food was chosen with multiple flavours in the diet. Table (2) shows the food and its costs, for this diet problem we are using the linear programming problem with the objective function and subject to constraint to minimum cost we have to spent for the food in problem.

Table 2. shows the diet chart with various food items with the costs for heart patient

Time period	Cost	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Beverages (x_1)	131	1cup tea & ½cup boiled chickpeas	1cup tea & 1cup of soup	1cup tea & 1 glass coconut water	1cup tea & ½ cup boiled green gram	1cup tea & 1cup of soup	1cup tea & 1 glass coconut water	1 glass fruit juice and 1 small banana
		15	18	20	15	18	20	25
Brunch Packets (x_2)	155	3idly with sambar	Pongal with chutney	2dosa with sambar & chutney	Rava upma & small banana	Oats kanji & 1cut apple	Veg panyaram with chutney	1cup kitchadi & 1 cut apple
		20	20	15	20	30	20	30
Dairy Drinks (x_3)	90	Buttermilk with ginger & mint	Buttermilk with mint	Buttermilk with masala papad	Buttermilk with wheat samosa	Buttermilk with green gram	Buttermilk with mint	Buttermilk with salad
		10	10	15	15	15	10	15
Lunch Packets (x_4)	255	Brown rice + dal + poriyal (carrot)	2multigrain roti + raita	Brown rice + dal +spinach	2multigrain roti + poriyal (cabbage)	Rice + curd + veg gravy	Multigrain roti + veg raita	Veg pullav + curd
		50	30	40	35	40	30	30
Snacks (x_5)	130	Green tea & roasted corn	Soup & 1plate cucumber	Baked vegetable	Tea/coffee with bhel	Sprouts salad	Green tea & roasted corn	Veg soup
		20	20	20	15	15	20	20
Dinner Packets (x_6)	240	2roti & cauliflower gravy	Brown rice with rajima sabji	Baked veg wheat parotta	Rice + rasam + roasted papad	Jeera rice + dal	Rice + veg gravy + poriyal (beetroot)	Millet roti + dal + raita
		35	40	20	35	35	40	35
Night drinks (x_7)	70	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)	1cup low-fat milk(with ginger and turmeric)
		10	10	10	10	10	10	10
Total		160	148	140	145	163	150	165

The above food items are planned according to the Pharm Easy website which is updated in the month of January 11, 2022 [9].

Solution:

Using the collected data from table (1), and denoting the values to the decision variable from the above proposed method, we formulated the diet problem as the following linear programming problem

Objective function:

$$\text{MIN } Z = 131x_1 + 155x_2 + 90x_3 + 255x_4 + 130x_5 + 240x_6 + 70x_7$$

Subject to constraints:

$$\begin{aligned} 15x_1 + 20x_2 + 10x_3 + 50x_4 + 20x_5 + 35x_6 + 10x_7 &\geq 160 \text{ (Monday)} \\ 18x_1 + 20x_2 + 10x_3 + 30x_4 + 20x_5 + 40x_6 + 10x_7 &\geq 148 \text{ (Tuesday)} \\ 20x_1 + 15x_2 + 15x_3 + 40x_4 + 20x_5 + 20x_6 + 10x_7 &\geq 140 \text{ (Wednesday)} \\ 15x_1 + 20x_2 + 15x_3 + 35x_4 + 15x_5 + 35x_6 + 10x_7 &\geq 145 \text{ (Thursday)} \\ 18x_1 + 30x_2 + 15x_3 + 40x_4 + 15x_5 + 35x_6 + 10x_7 &\geq 163 \text{ (Friday)} \\ 20x_1 + 20x_2 + 10x_3 + 30x_4 + 20x_5 + 40x_6 + 10x_7 &\geq 150 \text{ (Saturday)} \\ 25x_1 + 30x_2 + 15x_3 + 30x_4 + 20x_5 + 35x_6 + 10x_7 &\geq 165 \text{ (Sunday)} \\ x_1, x_2, x_3, x_4, x_5, x_6, x_7 &\geq 0 \end{aligned}$$

By using the linear programming problem and solved the diet problem, here we get the resultant optimum solution as the minimum cost for a week by the above food items. And the values are $X_1= 1, X_2= 1, X_3= 1, X_4= 1, X_5= 1, X_6= 1, X_7= 1$ denotes the quantity of foods in time period. The optimum cost $\text{MIN } Z = 1071$ as the final result of the problem is arrived.

III. CONCLUSION

The above method and numerical examples shows the cardiovascular disease impact on people. This study is about the increase in BP and the diet. Here BP is the major cause of CVD because of food intake, work stress, physical inactivity and etc... but the better changes can make in our daily routine as diet control. so the diet control problem is solved by LPP with minimum cost as Rs.1071. By maintaining the diet in our food intake which reduce the cause of CVD as well as all the major disease. The healthy life style leads to the successful long life.

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