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A LINEAR PROGRAMMING APPROACH TO DIET PLANNING FOR PEOPLE WITH HYPERTENSION

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ABSTRACT

Hypertension affects a lot of people in Zimbabwe and this places them at higher risk for cardiovascular diseases. High BP is associated with heart failure, possibility of a stroke, risk of a still birth (women) and possibility of kidney failure. There are a lot of survival strategies that can be taken to lower BP such as a DASH diet. A DASH diet is a critical component for cardiovascular disease risk reduction. A healthy dietary pattern that emphasizes fruits, vegetables, and low-fat dairy products and is reduced in fat and cholesterol can effectively lower BP. In this study a linear programming diet model was formulated for a hypertensive person with a 2000-daily-caloric need based on available local food and beverages in Zimbabwe. The objective was to obtain a daily minimum cost diet plan that meets the nutritional requirements for reducing high blood pressure. The linear programming technique addressed the problem of how to determine a healthy dietary pattern that would effectively help lower BP for people with hypertension. Numerical data was inputted into the diet model and an optimal diet plan for a day was obtained with a total cost of $2.76.

Keywords: Hypertension; Diet Planning: DASH; Linear Programming; Zimbabwe.

1. INTRODUCTION

Hypertension affects a lot of people in Zimbabwe and this places them at higher risk for cardiovascular diseases. High BP is associated with heart failure, possibility of a stroke, risk of a still birth (women) and possibility of kidney failure. According to Appel (2003), “High BP is one of the most important and common risk factors for atherosclerotic cardiovascular disease and renal disease.” Several studies on the prevalence of hypertension in Zimbabwe have recently been conducted. Marwiro (2010) studied the prevalence and risk factors for hypertension among Bulawayo City Council employees. The investigation by Marwiro (2010) was prompted by an “increase in the number of employees with raised blood pressure during routine medical examinations from less than two in every ten to four in every ten during the third quarter compared to the first and second quarters of 2009.” The prevalence of hypertension obtained was 34.4% and it was higher in females than males. The prevalence of undiagnosed hypertension was also found to be 14.2%. Marwiro (2010) concluded that, ”There was a high prevalence of both diagnosed and undiagnosed hypertension.” Chimberengwa (2013) evaluated the prevalence of hypertension at Vubachikwe mine in Gwanda, Zimbabwe. The prevalence of hypertension was 27.2% while males were 6 times more likely to develop hypertension compared to females. The study by Chimberengwa (2013) showed that “the prevalence is higher in males and increases with age.”

Mufunda et al (2006) in their study determined the prevalence rates of common non-communicable diseases in Zimbabwe by using centrally compiled public hospital-based data generated from 1990 to 1997. The prevalence rates of hypertension and diabetes increased three-fold during the study period. A follow-up urban blood pressure survey was carried out by Mufunda et al (2006) which “confirmed the status of hypertension as an epidemic, with a prevalence of 35% in women and 24% in men.” The prevalence of hypertension is high.

There are a lot of survival strategies that can be taken to lower BP such as a DASH diet. A healthy dietary pattern, termed the Dietary Approaches to Stop Hypertension (DASH) diet can effectively help to lower BP (Appel, 2003). “The DASH diet emphasizes fruits, vegetables, and low-fat dairy products and is reduced in fat and cholesterol” (Appel, 2003). Iwuji, Nnanna, & Ndulue (2016) argue that, “The DASH diet has been clinically proven to prevent and control hypertension.” Sacks et al (2001) said, “The effect of dietary composition on blood pressure is a subject of public health importance.” Patients are advised to use less fat and little salt in their meals. People with high BP are also encouraged to reduce weight as much as possible. Patients are encouraged to enjoy high roughage foods such as roller meal, brown bread, traditional sadza (for example, rukweza, mapfunde, mhunga and mupunga).

Iwuji, Nnanna, & Ndulue, (2016) formulated a linear programming (LP) model that provides a daily optimal DASH diet plan for people with hypertension. The model was based on food available in Nigeria. Their objective was "to obtain daily minimum cost diet plans that satisfy the DASH Diets' nutrients Tolerable Upper and Lower Intake for different daily Calorie Levels." Their diet model was illustrated by using real data with food samples derived from the DASH eating plan chart. They successfully formulated a diet model for a hypertensive person with a 2000-daily caloric need. The optimal diet plan for a day was obtained with a total cost of 944.41 Naira. It was the study by Iwuji, Nnanna, & Ndulue, (2016) that created the initial basis for this study. Linear programming has been widely used in diet planning. WHO (2005) evaluated the potential for various diets to meet nutrient needs for infants and children at 6-24 months of age by applying LP techniques. Health Department: Republic of South Africa (2013) used LP "to test how well different combinations of food and beverages, as recommended by the FBDGs, comply with standards for an adequate and prudent diet."

The objective in this study was to formulate an LP diet model for hypertensive people based on available local food and beverages in Zimbabwe. This would help us to come up with a healthy dietary pattern that would effectively help lower BP for people with hypertension.

2. THE LINEAR PROGRAMMING FORMULATION

The objective of the diet problem in LP is to minimize the cost of the diet subject to nutritional constraints. The LP model is given by:

$$\text{Max } z = \sum_{j=1}^{n} c_j x_j$$
$$\text{subject to}$$
$$\sum_{i=1}^{m} a_{ij} x_j \geq b_i,$$
$$x_j \geq 0,$$

where,
z is the objective function ($)
c_j is the cost of food item j ($)
x_j is the number of units of food item j in the solution
a_{ij} is the number of units of nutrients i one unit of food item j
b_i is the specific number of units of nutrient i required
m is the number of nutrients
n is the number of food items.
The diet model was illustrated by using real life data set in Table 2.1.
Table 2.1 Sample foods with their nutrient composition

	Foods (per 100g)						
Nutrients	Sadza (high roughage)	Bread (whole wheat)	Carrots	Banana	Milk	Fish	Peanut
Total Fat	1	1.8	0.2	0.3	3.6	1.18	47.8
Sodium	0	3	91.3	2.7	48.4	347	5.3
Calcium	3	41.5	35.7	7	118	15	58.1
Potassium	0	365	281.5	332	146.3	351	672
Calorie	115	334.6	35.5	94.7	66.3	109	591
Protein	9.5	12.5	1	1.3	3.2	22.6	27
Cost ($)	0.06	0.13	0.07	0.08	0.14	0.30	0.26

3. RESULTS AND DISCUSSION

The optimal diet plan for a day for an individual with 2000-carolic need was obtained using LP. Seven sample foods were chosen from food groups namely; grains, vegetables, fruits, milk, fish and nuts. The prices of the foods were collected from local shops and vegetable shops. Some of the nutritional content of the foods used in this study were obtained from Chitsiku (1989). The tolerable upper and lower intake level of the nutrients was obtained from Iwuji, Nnanna and Ndulue (2016).

Table 3.1 presents the optimal diet plan obtained. The expected nutrition composition and its comparison to the actual nutrient composition in the optimal diet plan was shown in Table 3.2.

Table 3.1 Optimal diet plan for 2000 calories per day

Foods	**Daily size (100g)**	**Cost of serving($)**
Sadza (high roughage)	3.00	0.18
Bread (whole wheat)	1.01	0.13
Carrot	3.78	0.25
Banana	3.72	0.30
Milk	9.26	1.30
Fish	2.00	0.60
Peanut	0	0
Optimal daily diet cost		2.76

Table 3.2 The comparison of the diet plan's expected and actual nutrient composition

Nutrients	**Lower and upper tolerable intake level**	**Quantity in optimal solution**
Total Fat	≤ 68	42.37
Sodium	≤ 1500	1500
Calcium	≥ 1334	1334
Potassium	≥ 4721	4721
Calorie	= 2000	2000
Protein	≥ 46	124.53

4. CONCLUSION

In this study an LP diet model was formulated for a hypertensive person with a 2000-daily-caloric need based on available local food and beverages in Zimbabwe. The LP technique addressed the problem of how to determine a healthy dietery pattern that would effectively help lower BP for people with hypertension. An optimal diet plan for a day obtained had a total cost of $2.76.

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